

# The Sierra Railway and the Transformation of California

Grade 4 Teacher's Guide





**Railtown 1897 State Historic Park**

4th Grade Unit Plan: The Sierra Railway and the Transformation of California

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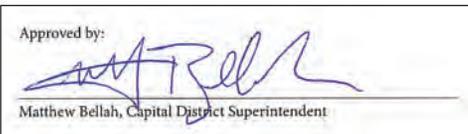
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Questions about this instructional unit should be directed to:

Railtown 1897 State Historic Park, 18115 5th Ave, Jamestown, CA 95327

## Unit Subject Focus

History—Social Science

## Primary Content Standard Addressed

*History-Social Science Content Standards for California Public Schools Kindergarten Through Grade Twelve*

- 4.4. Students explain how California became an agricultural and industrial power, tracing the transformation of the California economy and its political and cultural development since the 1850s.
- 4.4.4. Describe rapid American immigration, internal migration, settlement, and the growth of towns and cities (e.g., Los Angeles).

## Secondary Content Standards Addressed

*California Common Core State Standards English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects*

- Reading Standards for Informational Text K–5, Grade 4
- Key Ideas and Details 3. Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.

*California Common Core State Standards Mathematics*

- Grade 4, Geometry: Draw and identify lines and angles, and classify shapes by properties of their lines and angles.
- 1. Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures.

*History-Social Science Content Standards for California Public Schools Kindergarten Through Grade Twelve*

- 4.4. Students explain how California became an agricultural and industrial power, tracing the transformation of the California economy and its political and cultural development since the 1850s.
- 4.4.1. Understand the story and lasting influence of the Pony Express, overland Mail Service, Western Union, and the building of the transcontinental railroad, including the contributions of Chinese workers to its construction.

*Next Generation Science Standards*

- 4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and that their uses affect the environment.
- 4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electrical currents.

## Education and the Environment Initiative— Environmental Principles and Concepts Addressed

- Principle I: The continuation and health of individual human lives and of human communities and societies depend on the health of the natural systems that provide essential goods and ecosystem services.
- Concept a. Students need to know that the goods produced by natural systems are essential to human life and to the functioning of our economies and cultures.
- Concept b. Students need to know that the ecosystem services provided by natural systems are essential to human life and to the functioning of our economies and cultures.



**Sierra Railway Locomotive**

Photo courtesy of California State Railroad Museum

## Unit Grade Level

Fourth Grade

## Unit Duration

Lesson Number	Advanced Preparation (minutes)	Instructional Time (minutes)	Assessment Time (minutes)
1	15	60	30
2	30	120	45
3	60	120	30
4	15	75	30
5	15	90	30
6	15	60	30
Assessment: Traditional	15	N/A	60
Assessment: Alternative	15	N/A	Two sessions of 60 minutes each
Total	180	525	375

## Unit Overview

In this unit, students explore the history and lasting influence of the Sierra Railway Company of California (Sierra Railway) on the growth of industries and towns in Stanislaus, Calaveras, and Tuolumne counties. They learn about the region's natural resources that were extracted or harvested locally from mines and forests. The Sierra Railway transported these resources within the region as well as throughout the country via the transcontinental railroad network.

In the first lesson, students are introduced to Ruth and Peter, two fictional siblings. The siblings have moved to Oakdale in 1897. They keep a diary of events affecting their community, augmented with newspaper clippings that follow the construction of the Sierra Railway. The first reading and class discussion establishes a foundation of knowledge upon which the next five lessons in the unit are based.

In the second lesson students examine topographic maps of the local area to predict where the track for the Sierra Railway will be laid. They learn about challenges caused by the terrain and engineering solutions that enabled a train to travel safely from place to place.

The third lesson uses hands-on activities about energy transfer to explore how this concept applies to a working steam locomotive.

In the fourth lesson, students work in small groups to develop a plan for the growth of a town. They identify resources migrants will need, determine the origins of those resources, develop strategies to recruit people with knowledge to build and manage the town's industries, and figure out how to generate the funds to sustain the town and pay workers. They view each other's plans and then vote on the one they think will work best.

In the fifth lesson, students analyze charts from historical annual reports of the Railroad Commission to learn more about the Sierra Railway's role in the growth of local industries and towns. They calculate differences in travel time between different methods of transport, identify changes over time in the type of freight the Sierra Railway transported, and they discover the route connections between the Sierra Railway and transcontinental railroads.

In the final lesson of the unit, students are reunited with their lesson four groups to consider the effects of water supplies, both abundant and scarce, on their towns. In this context, they learn that the Sierra Railway was used to transport construction materials and workers for three major dam projects in the 1920s and 1930s.

The unit helps students understand the role the Sierra Railway had on the growth of local industries, regional economies, and towns by transporting goods produced by natural systems.



# Railtown 4th Grade Unit Plan

## Lessons at a Glance

### *Lesson 1: Rise of the Sierra Railway*

Students read a passage from a diary written by a brother and sister who migrate to Oakdale. It focuses on the impending development of the new Sierra Railway route. The teacher leads students in a classroom discussion and poses factual, interpretive, and predictive questions about the text.

### *Lesson 2: Laying Track*

Students read the next entry in the siblings' diary and are challenged to use topographic maps of the region to predict the route that will be chosen by Sierra Railway engineers. Students learn about engineering and mathematical solutions used by railways to deal with difficult terrain and also about freight and passenger transportation requirements and constraints involved in laying track.

### *Lesson 3: The Science behind a Steam Locomotive*

Students engage in various hands-on activities to help them understand that energy can be transferred from place to place through various means as well as converted from one type of energy to another. Students are then able to apply these energy concepts to understand how a steam locomotive works.

### *Lesson 4: Planning a Town*

Students use another entry from the siblings' diary as a launching point to work in small groups to design and plan the growth of a town along the Sierra Railway route. They consider the immediate needs migrants to the town will have, as well as infrastructure that needs to be created to host and sustain the growing population.

### *Lesson 5: A Network of Iron*

Students examine multiple data charts from historical annual reports of the Railroad Commission to learn about resources transported by the Sierra Railway (including its own fuel source), its critical connections to the national railroad network via the Santa Fe and Southern Pacific railroads, and how the Sierra Railway's efficient transport resulted in the growth of local industries.

### *Lesson 6: Driving Forces of Resources*

Students learn through the siblings' diary that two decades have passed and the Sierra Railway is now also involved in transporting workers and construction materials to local dam construction sites. Working in small groups, students analyze two scenarios affecting their towns from Lesson 4, one in which water is a scarce resource and another in which it is abundant. They create a Cause and Effect chart to document the results of the two scenarios.

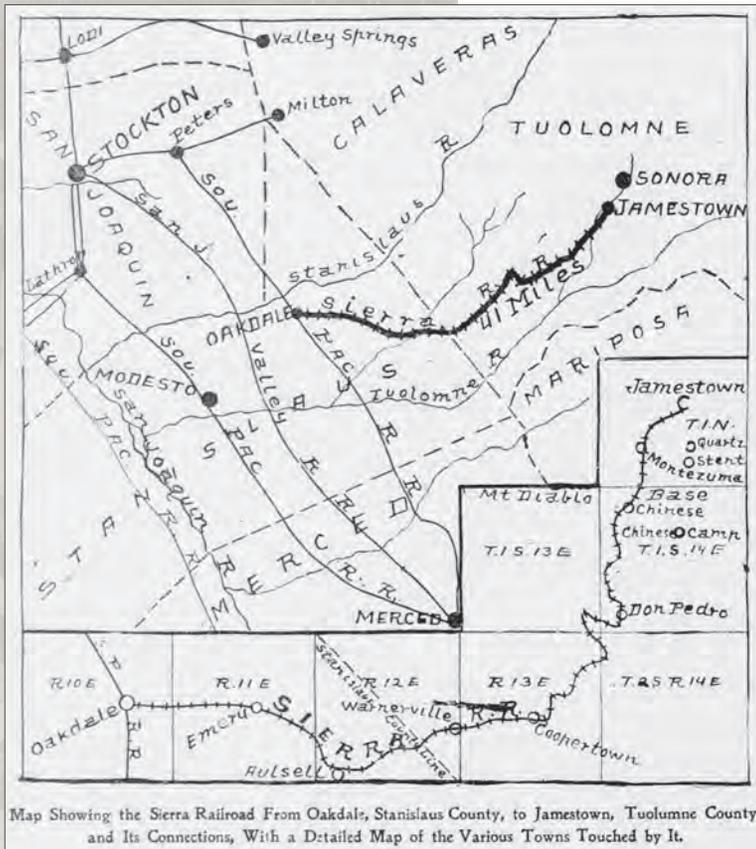


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## Background

The Sierra Railway of California, a standard gauge shortline traveling from the Sierra Nevada foothills to the Central Valley, played a role in California's history. It transported natural goods not only throughout the local regions, but also to the rest of the country through its connections with transcontinental railroads.

The discovery of gold in California in 1848 resulted in rapid migration, settlement, and the growth of towns and cities when people came in search of prosperity. As people extracted ore, timber, and other natural resources, or goods, they became more difficult to obtain. People had to adjust equipment and refine extraction methods, particularly to continue mining for gold. Within a decade, hard rock mining replaced placer mining; however, soon afterwards it became uneconomical to recover gold from deep within the earth. This changed in the 1890s, when new processes made it economically feasible to re-open many mines.

The 1890s brought a second gold rush to the Mother Lode area in California. There, in the foothills of the Sierra Nevada, the promise of gold and abundance of timber drew people who soon encountered logistical challenges. Moving these ecosystem goods throughout and between the Sierra foothills and valley was slow. Stagecoaches and mule trains could transport goods, but a shipment between Sonora and Oakdale could take several days. In addition, winter rain and mud would slow down or stop the stages, halting transport of freight. This in turn would result in mills shutting down due to lack of timber to process. The solution came in the form of railways.

The Sierra Railway was incorporated on February 1, 1897 to “purchase, construct, maintain, operate and conduct a railroad of standard gauge in the state of California to be operated by steam, electricity or any other motive power, for the carrying of passengers and freight.”<sup>1</sup> Four men were at the core of this company: Thomas S. Bullock, a railroad builder who already

<sup>1</sup> *Minutes of the Board of Directors of the Sierra Railway Company of California, February 1, 1897 (Bancroft Library Collection). As quoted in Connery, “When the Railroad Came to Tuolumne,” 1258.*

had completed three railroad projects; Sidney D. Freshman, a skilled business man; Prince André Poniatowski, the president of the California Exploration Company that had purchased many abandoned mines in Amador and Calaveras Counties and saw the advantage of getting low-cost electric power to the mines, and William H. Crocker, a banker who served as one of the financial backers of the new Sierra Railway. When the company was first incorporated, the exact route was not determined, but the men wanted to start in Stanislaus County and head east and northeast to the town of Angels Camp in Calaveras County. Not only would this serve many mines along the route, but it would also reach the Calaveras Big Trees region near to where the Crocker and Poniatowski families had timber holdings.

One of the many challenges of finding a suitable route included obtaining right-of-way. Anthony Arnold, the Sierra Railway's right-of-way agent, found some landowners were willing to allow the track to traverse their land in return for free passenger travel or improved transportation for their goods. Other landowners required payment for the use of their land.

Originally, Crocker and Poniatowski wanted the line to begin in the Stockton area. Eventually, however, they decided to start the Sierra Railway line at Oakdale. This town was also a depot for the Southern Pacific Railroad, a transcontinental railroad, which resulted in a direct connection between the Sierra Railway and the rest of the country. Grading work began in Oakdale on March 24, 1897.

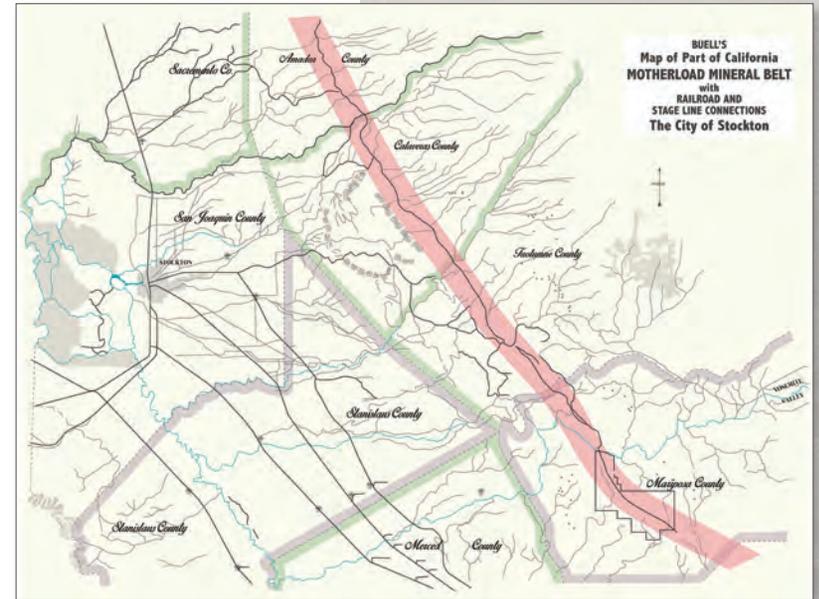
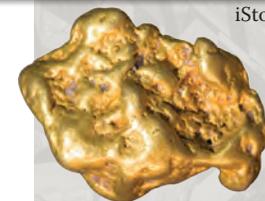


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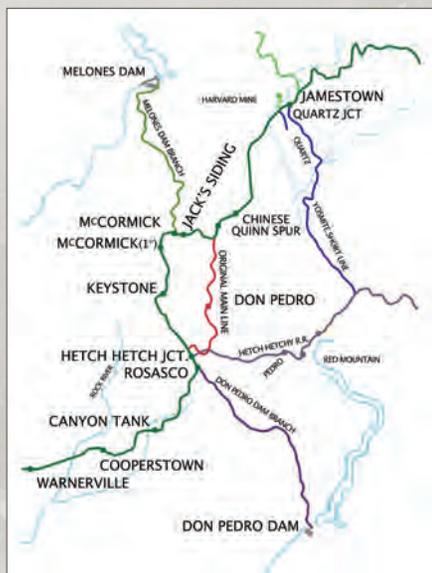


Illustration by Amy Hay

Not everyone was excited about the arrival of the railroad. Some teamsters (stagecoach drivers) were concerned about the economic impact the railroad would have on their business. At this time, they were the only method of transportation for passengers and freight traveling between towns. Stagecoaches left Sonora at 9 a.m. and arrived in Oakdale by 7 p.m. This ten-hour journey would be significantly shortened by the Sierra Railway's new line. The Sonora Democratic Banner declared on April 2, 1897, "No one knows the impact — it will eliminate the teaming but will greatly help development of the marble quarry, lime deposits suitable for use, granite deposits, increase fruit production and will increase population and open up the country."<sup>2</sup>

The first part of the rail line, a nineteen-mile stretch from Oakdale to Cooperstown, was completed in June 1897. At this time, raising and selling cattle was the main source of income in this area. The Sierra Railway transported cattle from the ranchers' fields to market. Prior to this new mode of transport, the ranchers had to walk their cattle to market, which resulted in undesired weight loss in the cattle.<sup>3</sup> Teamsters quickly adapted and began service to and from Cooperstown to meet the transportation needs of passengers and freight. Now rather than transporting them from starting destination to final destination, the stages were providing short-distance transportation between Cooperstown and the final destination.

The second stretch of track was finished by August 12, 1897. Don Pedro, a new town created as a result of the railroad, became the new end of track. The twelve miles of track to Don Pedro were harder to construct than the previous nineteen miles because of elevation gain and the need to build two bridges to cross Dry Creek Canyon. Although a local newspaper had great hopes for Don Pedro becoming a flourishing town<sup>4</sup>, the reality was that the difficult terrain was a limitation. The teamsters who met up the train had little space to queue. The rail sidings that were built were

too short to meet the needs of both the teamsters meeting trains and the railcars that the railroad was using to continue building the line. As a result, freight had to be unloaded, covered, and then loaded into stages, which sometimes resulted in damage to or delay of the goods. Don Pedro closed as a regular station soon after Chinese Camp was reached. In December of 1898, the rail line was rerouted seven miles west through the Keystone area to avoid the difficulties resulting from the original bridges, grading, and curves in the Red Hills area by Don Pedro.

San Francisco Call  
November 11, 1897

## JAMESTOWN ENJOYS A HOLIDAY.

Five Thousand People Celebrate the  
Completion of the Line.

Oratory, a dance and fireworks.

Head of the Company Presents a Money  
Gift to the Terminal City's School.

Special Dispatch to The Call.

JAMESTOWN, Nov. 10.— The golden spike was driven today in the last tie of the Sierra Railway, signaling the completion of the line to this terminus. A more propitious day could not have been had. Fully 5000 people attended the celebration, and never before did the streets of Jamestown present such an animated appearance.

California Digital Newspaper Collection, Center for  
Bibliographic Studies and Research, University of  
California, Riverside, <http://cdnc.ucr.edu>.

The *San Francisco Call* celebrates the arrival of the  
Sierra Railway into Jamestown.

<sup>2</sup> *Democratic Banner*, April 2, 1897. As quoted in Connery, "When the Railroad Came to Tuolumne," 1261.

<sup>3</sup> Connery, "When the Railroad Came to Tuolumne," 1261.

<sup>4</sup> *Ibid.*

Passenger service between Oakdale and Chinese Camp began on October 5, 1897, and the first freight shipment occurred on October 14, 1897. Jamestown was reached on November 8, 1897. Although the distance between Chinese Camp and Jamestown was only six miles, to connect the two towns required constructing the largest bridge on the line thus far over Woods Creek. The arrival of the train into Jamestown was celebrated on November 10, 1897.

The arrival of the Sierra Railway into Jamestown resulted in immediate cultural development and economic growth in the town. A two-story General Office building attached to the long freight depot was completed in November 1897. By the end of January 1898, the train's turntable was complete and the roundhouse was under construction. On April 18, 1898, the Hotel Nevills, the largest hotel in Tuolumne County, had its grand opening. This hotel was meant to serve the Sierra Railway tourists coming into the area from San Francisco and other locales. Thomas Bullock and W.A. Nevills, a wealthy man who was the owner of a nearby gold mine, formed a partnership to build the hotel. The Sierra Railway passenger offices were strategically located in the lobby of Hotel Nevills.

Bullock, Crocker, and Poniatowski had great plans to profit from the arrival of the railroad. They organized the Jamestown Improvement Company to grow the town. They planned the Pereira Addition to develop 120 acres near the depot to house railroad workers and their families, including Bullock. Soon other residences were constructed to house the growing community. The town's infrastructure was developed with numbered streets and water, electric, and sewer systems.

Bullock had made an agreement with Nevills to not extend the line beyond Jamestown for five years, thus ensuring the economic development of the town and additional wealth for Nevills and his hotel. However, with its terminus in Jamestown, the railroad still was not meeting the needs of area mines nor Poniatowski's, Crocker's, and Bullock's plans to develop the timber industry. Bullock reneged on his agreement and began working to extend the line.

Where to go next and how to get there was not immediately obvious. The desire to extend the line to Angels Camp was strong, but the terrain was arduous. The railway's original engineer quit, saying that track could not be laid to the mining town.

At the same time, a decision had to be made. Other companies were poised to come in and take a share of the business. The Stockton and Tuolumne Railroad, dubbed the Women's Railroad because its president was female, was threatening to push its way towards the foothills in Tuolumne County. The owners of the Sierra Railway did not want to risk another rail company taking its customers. In addition, they had timber interests in the foothills of the Sierras and wanted to transport their freight using their own company. In the town of Columbia, north of Sonora, marble, which could possibly be used as building material in the Bay Area, was being extracted from quarries. Poniatowski, Bullock, and two other Sierra Railway directors leased Columbia Marble Works hoping that their investment would bring additional wealth. Transport of the marble would only be possible if their line to Sonora was completed.

In July 1898, William H. Newell was hired as Sierra Railway's Engineer in Charge of Location and Surveys. In the end, it was determined that the best option was to extend the line to Sonora, and then onto Carters/Summersville (later renamed Tuolumne City in 1909). This would allow access to the men's timber interests, as well as the transport of marble quarried by Columbia Marble Works.

In early September 1898, work began on the line from Jamestown towards Carters/Summersville. William H. Newell, now the Chief Engineer of the Sierra Railway, worked on the new track. He also oversaw rerouting the line away from Don Pedro to the Keystone area. On February 26, 1899, the Sierra Railway arrived in Sonora. The first floor of the depot was sheathed with white Columbia marble and the second story was built with Tuolumne



**Hotel Nevills**

Photo courtesy of Tuolumne County Historical Society



**White Marble**

Photo courtesy of California State Parks

San Francisco Call  
February 26, 1899

## FIRST TRAIN INTO SONORA

Rejoicing in the  
Mountain Town.

### Special Dispatch to the Call

SONORA, Feb. 25 — The greatest demonstration held in Sonora in years took place this evening, the occasion being the arrival of the first passenger train over the Sierra Railway. The Columbia cornet band was at the depot at 5 o'clock, and 3000 people were present. At 5:10 the special from Jamestown arrived with 200 visitors. When the train stopped, seventy-five giant powder cartridges were exploded. At 5:23 the first regular passenger train arrived. George W. Wright, the popular engineer of the road, who has the honor of having been born in Sonora, brought the first train into the city.

California Digital Newspaper Collection, Center for Bibliographic Studies and Research, University of California, Riverside, <http://cdnc.ucr.edu>.



Angels Branch Combination Coach/  
Baggage Car

Photo courtesy of California State Railroad Museum

County wood, showcasing the resources — holdings of the directors of the Sierra Railway — that the train would transport. As the Sierra Railway expanded, many of its directors acquired other businesses in the area. Soon after the line reached Sonora, the Sierra Railway owners purchased a mill site for their timber, and in 1899 they incorporated the West Side Flume and Lumber Company. Bullock built a depot for the Sierra Railway near the site of their lumber company, knowing that the Sierra Railway would continue on to Carters/Summersville, which it reached on February 1, 1900. Later that same year, the West Side Flume and Lumber Company incorporated the Hetch Hetchy and Yosemite Valley Railroad that used a narrow gauge track to transport timber. Several Sierra Railway directors also had a hand in incorporating the Standard Lumber Company. With the railway now in service between the foothills and valley, there were profits to be made in the timber industry. In November 1901, Bullock opened Turnback Inn, near Tuolumne City, hoping to host tourists traveling to Yosemite.

Work started on the Angels Camp line in August 1899, but encountered many challenges. The geography between Jamestown and Angels Camp posed a significant obstacle due to elevation changes, hills, and river and canyon crossings. A trestle (railroad bridge) spanning the Stanislaus River was built ahead of time so it would be ready for the track. While Bullock thought that mining company landowners would be delighted to grant passage to the Sierra Railway, this was not always the case. At one point, due to right-of-way difficulties, Bullock declared the track would only go to Tuttletown. This rendered the bridge crossing the Stanislaus River useless. He attempted to sell the bridge to county government, but luckily for the Sierra

Railway, as the bridge did eventually end up being used by the train, the sale failed. At another point, Bullock proposed building an aerial tramway between Tuttletown and Angels Camp. His tramway route purposefully skipped landowners who had been challenging him on right-of-way issues; once they recognized that easy transport would not be available to them, some relented.

The first train traveled into Angels Camp on September 15, 1902. Two custom short 32-foot long passenger cars, one a combination coach (passenger)/baggage car and the other a coach car, were built for the Angels Camp line. These cars were about half of the length of the typical coach cars in use on other rail lines. While in service, the line ran a round-trip train six days each week. Each train had both coach and freight cars on it. The Sierra Railway built four open-air excursion cars that traveled between Jamestown and Angels and carried tourists on a remarkably scenic 19-mile route that included switchbacks and views from Gee Whiz Point down into a river canyon. Passengers traveled in these open-air cars between Tuolumne and Calaveras counties for special events such as dances, baseball games, and holiday celebrations.

Although the train did not reduce the transport cost of all freight, it did so for many items and also allowed for efficient transport of low-grade ores to the Selby smelter at Carquinez Straits on the San Francisco Bay in Contra Costa County. Several years later, the Sierra Railway was ordered to change its pricing structure because the California Railroad Commission found that it was favorably pricing its own goods (timber) and charging other goods too much.

Through its connection to the transcontinental railroad network in Oakdale, the Sierra Railway played an integral role transporting goods from Tuolumne, Calaveras, and eastern Stanislaus counties throughout the country. The Southern Pacific Railroad and the Atchison, Topeka and Santa Fe Railway (Santa Fe Railway) had branch lines with stations in Oakdale. From there, the Southern Pacific traveled to Stockton, where it connected to San Francisco, Los Angeles, Portland, Ogden, and New Orleans, among other cities. The Santa Fe Railway ran from

# The Sierra Railway and the Transformation of California

the Bay Area through the San Joaquin Valley. It continued on to Los Angeles and San Diego, before heading east to Arizona, New Mexico, Chicago, and Texas.

Over time, as the local economy changed, the Sierra Railway adapted. As the population in the area increased, and with it, the need for water for irrigation, agriculture, and city services, the Sierra Railway was employed in the construction of dams. The Hetch Hetchy Railroad was built by the city of San Francisco in 1916 with track starting on milepost twenty-six of Sierra Railway's main line. The Sierra Railway transported construction equipment and materials to Hetch Hetchy Junction where the freight was transferred to the Hetch Hetchy Railroad. The freight then traveled to Hetch Hetchy Valley at the northwestern section of Yosemite National Park. There, O'Shaughnessy Dam was being constructed to capture and store Tuolumne River water in the Hetch Hetchy Reservoir. The project was completed in 1923 with the support of the Sierra Railway.

In 1921, an eight-mile spur was built by the Sierra Railway to serve the construction needs of the Don Pedro Dam, which was completed in 1924. A seven-mile Sierra Railway spur was built in 1925 to serve the Melones Dam site on the Stanislaus River. All three dams were also used to create hydropower. From May 1935 through 1938, the Sierra Railway was contracted to operate the Hetch Hetchy Railroad and transport materials needed to increase the height of the O'Shaughnessy Dam to meet the increasing needs of the growing population in the Bay Area.

The Depression years were hard on the Sierra Railway. The Sierra Railway Company of California went into receivership in 1932. In 1937 it was sold at public auction and emerged as the Sierra Railroad Company.

Throughout its life, the Sierra Railway was tied to the transport of goods produced in Calaveras, Stanislaus, and Tuolumne counties: gold, limestone and other minerals; marble and other cut stone; livestock, wheat, fruit and other agricultural products; and most

especially lumber. The train itself was fueled by natural resources: first coal, then oil. The rise of the railway was followed by the economic and population growth of towns along its route. Townspeople could efficiently transport their freight across the foothills and valley or across the country. Today the Sierra Railway's history is preserved by California State Parks at Railtown 1897 State Historic Park, as well as in many movies and television shows that feature the beautiful locomotives and cars of the historic Sierra Railway.



**Sierra Railway Turntable**  
Photo courtesy of Helen de la Maza



**Old Don Pedro Dam**  
Photo courtesy of CA-A-0014, WaterArchives.org

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## Unit Assessment — Traditional

### Advanced Preparation Time

15 minutes

### Materials

- Pencil (one per student)
- Unit assessment handout (one per student)  
*See Appendix for reproducible handouts.*

### Part 1. Choose the best answer (2 points each)

1. Choose the event that did NOT happen during the history of the Sierra Railway.
  - a. difficulty obtaining right-of-way
  - b. locomotives were fueled by coal
  - c. line extended into Yosemite National Park (answer)
  - d. transported timber, ores, cattle
2. \_\_\_\_\_ is the physical movement of people from one area to another.
  - a. extraction
  - b. migration (answer)
  - c. resource
  - d. switchback
3. A train car must run on two \_\_\_\_\_ rails in order for the car to stay on the tracks.
  - a. perpendicular
  - b. parallel (answer)
  - c. triangular
  - d. circular

4. Which of these does NOT describe a way the Sierra Railway made money?
  - a. transport of timber
  - b. passenger tourism
  - c. building of dams
  - c. aerial tramway (answer)
5. Which geographic feature made laying the track challenging?
  - a. rivers
  - b. canyons
  - c. mountains
  - d. all of the above (answer)

### Part 2. Answer each question with a sentence or short paragraph (5 points each)

11. List two engineering problems the Sierra Railway engineer encountered and describe one solution for each problem.  
*(answers will vary, but may include:*  
*hill — switchback or cut*  
*canyon — bridge*  
*river — bridge*  
*tight turns — shorter cars*
12. Describe the relationship between goods produced by natural systems and the growth of towns.  
*(Goods in the area included timber, crops (wheat, fruit, etc.), animals (livestock), water; and gold, limestone, marble and other rocks and minerals. Timber was used in buildings. Crops were mostly eaten locally, although some were shipped. Some crops were used to make clothing. Animals were eaten locally or shipped out. Milk from cows was used to make dairy products. The Sierra Railway transported many of these goods. People migrated to areas where resources and jobs existed. This resulted in towns growing along the Sierra Railway route.)*

13. Describe why the connection at Oakdale between the Sierra Railway and the Southern Pacific Railroad or the Santa Fe Railway was so important in the growth of the economy and towns.

*(Before the Sierra Railway was built, people and goods were transported by stagecoach and mule-hauled freight wagons. Neither could carry a lot at once. Trains could carry more at once. Stagecoaches and freight wagons took a long time to travel between towns and were best suited to mild weather. The train moved faster between towns and could run in heavy rain and hot, dusty days. Once the Sierra Railway was built, goods were transported more efficiently to Oakdale. Once in Oakdale, those goods could be transferred to the Southern Pacific Railroad or the Santa Fe Railway to be taken to other parts of the country. This allowed local goods to reach markets beyond the county. This more efficient transport allowed for increased production and higher income for companies. More jobs were created and people migrated to the area for the jobs and money.)*

14. Describe why towns, cities, and farms need access to reliable water sources in order to experience economic and population growth.

*(Without water farmers and ranchers can't grow crops or raise animals. People also need water to drink, cook, and bathe. Water also helps put out fires. Water is used in many industries to make products. People migrate to places where resources are available so they don't have to travel or pay too much for them.)*

**Part 3. Follow the directions in the question below (10 points)**

15. Circle in the diagrams below at least two transfers of energy that take place while a locomotive is functioning. In the lines below, describe the transfers of energy.

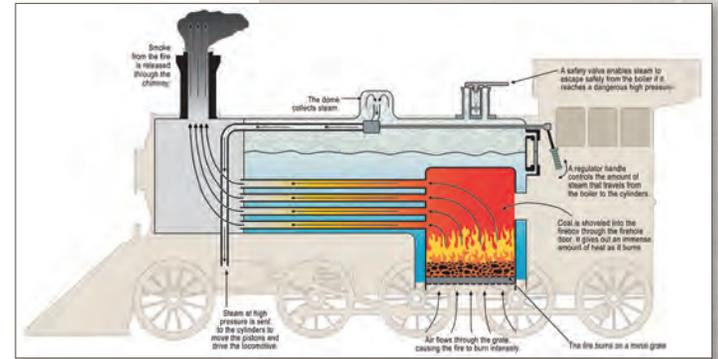
*(See Appendix for reproducible full-size diagrams.)*

*(answers will vary and may include: fuel to burn to heat firebox, firebox to heat water in boiler, water conversion into steam, steam into cylinders to move them, cylinder motion to drive wheels via main and side rods, wheels turning to motion along the track.)*

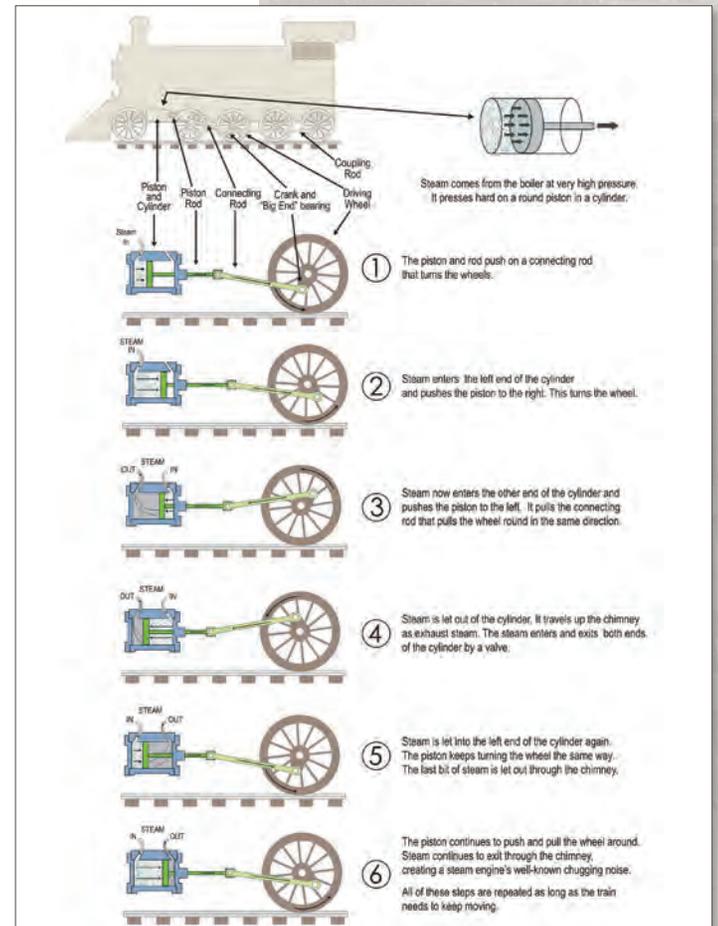
**Part 4. Follow the directions in the question below (20 points)**

16. Write one paragraph with at least five sentences summarizing the lasting influence of the Sierra Railway in the local region by including multiple cause and effect sequences you have learned throughout the unit.

*(The Sierra Railway played a big role in the growth of towns and the economy. The Railway connected three counties that had different natural goods. Carters/Summersville was near timber and lumber mills. The Angels Camp line traveled near many different mine companies. The mine companies were able to transport their ores on the Sierra Railway. Before, it was too expensive to transport on stagecoach to the smelting plant. The Sierra Railway had a depot at Oakdale, where two branch lines of transcontinental railroads met the Sierra Railway. The transcontinental railroads transported goods from the area throughout the country. The Sierra Railway also transported construction materials and people for dam building. As more jobs became available, more people migrated to the area. This led to the growth of towns.)*



Both illustrations by Amy Hay



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## Unit Assessment — Alternative — Cause and Effect Web Poster

### Advanced Preparation Time

15 minutes

### Assessment Time

Two in-class sessions of 60 minutes, plus additional out-of-class time as determined by teacher

### Materials

- Markers: colored, thin and thick (enough for students to share and have multiple colors)
- Masking tape (one roll per class)
- Pencil (one per student)
- Poster paper (one sheet per student)
- Scratch paper (multiple sheets per student)
- Sierra Railway of California Directors Conference: Cause and Effect Poster Session handout (one per student)
- Sierra Railway of California Poster Session Q & A handout (one per student)  
*See Appendix for reproducible handouts.*

### Procedures

#### Session 1

1. Explain to students they will participate in a poster session at a conference of Sierra Railway of California directors. Poster sessions are opportunities to learn information in a short period of time. Students will prepare posters that describe what they have learned throughout the Sierra Railway unit. During the poster session, they will read each other's posters and ask questions.

2. Distribute a copy of Sierra Railway of California Directors Conference: Cause and Effect Poster Session to each student. Review the instructions with them and answer any questions. Inform students when their posters are due. Encourage them to create a draft on scratch paper of their poster to clarify their thoughts first.
3. Distribute supplies to students.
4. Inform students if they are to complete their posters during out-of-class time.

#### Session 2

1. Post students' completed posters around the room. Divide students into two groups. Have the students in Group One stand by their posters.
2. Distribute a copy of Sierra Railway of California Poster Session Q & A to students in Group Two. Explain to students that Group Two will have fifteen to twenty minutes to view their colleagues' posters, ask questions, and record their conversations on the handout.
3. Reverse the roles so Group Two students are standing by their posters and Group One students review posters, ask their colleagues questions, and document their answers on the handout.
4. Bring the class together and have several volunteers share what they learned during the poster session. Collect the posters and students' copies of Sierra Railway of California Poster Session Q & A for use in assessment.

## Extension Ideas

#### Lesson 2:

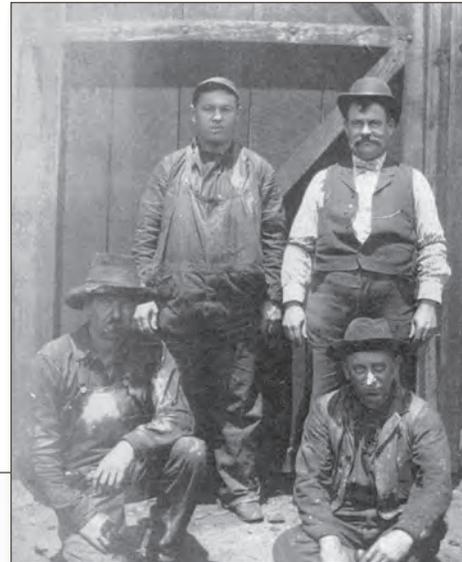
Provide the students with craft sticks and other building materials and challenge them to construct a bridge that spans a thirty-centimeter river and that can hold, for instance, 200 pennies in a cup, without collapsing.

## Historic Sierra Railway Photos



above: Lumber Mill

Photo courtesy of Tuolumne County Museum



above: Workers at First Roundhouse Circa 1906

Photo courtesy of California State Parks

left: Train on Bridge

Photo courtesy of Tuolumne County Museum



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## Resources for Teachers

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# Lesson 1: Rise of the Sierra Railway

## Subject Areas

- English Language Arts, History-Social Science, Science

## Advanced Preparation Time

- 15 minutes

## Instructional Time

- 60 minutes

## Assessment Time

- 30 minutes

## Learning Outcomes

- Students will be able to explain at least three events related to the Sierra Railway based on specific information in a text.
- Students will be able to define the word migration.
- Students will be able to describe that the Sierra Railway steam locomotives originally used coal as a source of fuel to transfer energy to move the trains.

## Key Vocabulary

**Extract:** to take out.

**Ecosystem goods:** materials, such as timber and water that are produced by natural systems and used by human communities

**Migration:** the physical movement of people from one area to another

**Ore:** rock that contains minerals with metals like gold or nonmetallic material that can be extracted for profit

**Right-of-way:** the legal right to pass along a route through property belonging to another person or entity

**Transport:** to move from one place to another

## Summary

In this lesson students are introduced to Ruth and Peter, nine-year old twins who have just moved to Oakdale and eagerly record their experiences with, and thoughts about, the Sierra Railway in a new diary. Students read the siblings' first diary entry to learn about the new Sierra Railway route that will be built from Oakdale to Jamestown, Angels Camp, and Sonora. Once students have read the material, the teacher leads a classroom discussion by posing factual, interpretive, and predictive questions to the students. This lesson provides the foundation for the remainder of the unit in which students will learn about the Sierra Railway's influence in the growth of towns and California's economy.

## Materials

- Digital projector, computer, and screen if projecting the reading
- List of discussion questions (included in Procedures)
- Pencils (one per student; consumable item)
- Projectable Lesson 1 reading if applicable
- Student workbook (one per student; consumable item)
- Word wall card: migration

## Advanced Preparation

1. Familiarize yourself with the Lesson 1 reading as well as the suggested questions in the Procedures section. Adapt the questions as needed to accommodate your students' needs.

## Prerequisite Knowledge

Listening and speaking skills. Ability to ask for clarification, summarize, paraphrase, and build on another person's ideas to engage in rich, meaningful discussion.

## Background

The Sierra Railway was incorporated on February 1, 1897 with the original intention, as per the Board of Directors' meeting, of creating a line that would serve the transportation needs of area mines in Calaveras and Stanislaus counties as well as the timber industry in Calaveras County. Although the minutes of the Board of Directors' meeting did not mention that the route would travel to Tuolumne County to serve the timber industry, this was also an apparent need. Mineral and timber extraction were the strongest regional industries at the time the Sierra Railway was incorporated.

Prior to the construction of the Sierra Railway route, the transport of freight and people across the three counties relied on stagecoaches and freight wagons pulled by mule teams. The advantage of these was that they could travel from one specific point to another. However, travel time was slow and inefficient for transporting freight. Once the Sierra Railway track was built, travel time between locations with depots was reduced. However, stagecoaches were still needed to transport mail and passengers, and mule teams to transport freight, between other locations and the train depots. As a result, sometimes the train trip took just as long as taking a stage directly from point to point. The mines along the Angels Camp line, however, benefited greatly from the Sierra Railway as greater profits could be made from extracting low-grade



**Sierra Railway No. 3 Locomotive**

Photo courtesy of California State Railroad Museum

ore and transporting it to a smelting plant via train. Before, with only teamsters available, the expense of transport was not worth the income.

The Sierra Railway locomotives were steam engines fueled initially by the combustion of coal, then oil once oil-burning technology for locomotives was developed. Fueled by one natural good while transporting others, the railway system was largely dependent on the region's natural systems. The same was true for the communities in this region. The prosperity and well-being of their residents were directly dependent on the health of the natural systems that supported their economy.

The Sierra Railway's presence in Stanislaus, Calaveras, and Tuolumne counties influenced the growth of towns, especially where depots were located. Initially workers migrated to the area to construct the track and depots. Once the route was active, industries became more profitable with more efficient transport of natural goods. Internal migration to the area of workers, business people, and their families resulted in the growth of communities. Seasonal migration also occurred with families who came in the spring to work in the logging industry and left in the fall.

The four men involved in starting the Sierra Railway, Bullock, Poniatowski, Crocker, and Freshman, had financial interests in many area industries. As time passed and their track was constructed, they became involved in many more companies and partnerships that would reap profits.

## Procedures

### *Introductory Information*

1. Have students turn to a neighbor and share something they know about trains or railroad tracks. Have a few students share what their partners said. (Answers will vary.)
2. Explain to students that for the next (few weeks or several days) they will be learning about the Sierra Railway and its lasting influence—historically, economically, and culturally—in the local region. Tell students they will read the diary of a brother and sister



**Sierra Railway No. 3 Locomotive, 2016**  
Photo courtesy of Kathy Syverson

who lived in Oakdale, the starting point of the Sierra Railway's route, and learn along with the siblings as they explore the planning and operation of the railway.

### *Presenting the New Material/Practicing the New Material: Step-by-Step Procedures*

1. Distribute a student workbook to each student. Have them write their names on the cover.
2. Have them turn to page 4 titled "Rise of the Sierra Railway." Explain that they will read this section and then answer questions through a class discussion. Review the questions they will be answering and encourage students to think about the answers as they read.
3. Give students time to read the story. (Note: The story can be projected and read out loud by you or by students who are strong readers).



**Thomas Bullock**  
Photo courtesy of Tuolumne County Historical Society

# Lesson 1: Rise of the Sierra Railway

## Standards Connections

### California Common Core English Language Arts Standards

- Reading Standards for Informational Text K – 5, Grade 4 Key Ideas and Details 3. Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.

### History-Social Science Standards

- 4.4. Students explain how California became an agricultural and industrial power, tracing the transformation of the California economy and its political and cultural development since the 1850s.
- 4.4.4. Describe rapid American immigration, internal migration, settlement, and the growth of towns and cities (e.g., Los Angeles).

### Next Generation Science Standards

- 4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and that their uses affect the environment.

## Environmental Principles and Concepts

- Principle 1: The continuation and health of individual human lives and of human communities and societies depend on the health of the natural systems that provide essential goods and ecosystem services.
- Concept a: Students need to know that the goods produced by natural systems are essential to human life and to the functioning of our economies and cultures.

4. Ideally students should be seated in a circle for the class discussion so they can speak to, and engage with, each other in addition to you.

5. Facilitate a class discussion using the questions that follow or as a guideline. Start with factual, then interpretive, and finally, predictive questions and encourage students to support their claims by identifying the supporting evidence in the text. Encourage students to use academic conversation strategies such as asking for clarification, summarizing, paraphrasing, and building on each other's ideas to engage in rich, meaningful discussion. This class discussion provides students with an opportunity to practice reading an informational text and explaining it based on specific information in the text.

### Factual Questions:

1. To which town have the siblings moved? *Oakdale*
2. To which cities will the train travel? *Jamestown, Angels Camp, probably Sonora.*
3. Which mode of travel is faster if the paths are direct: stagecoach (horse and wagon) or train? *Train.*
4. Who lives in a town that the brother and sister are excited to visit? *Grandparents.*

### Interpretive Questions:

1. How do you think the children feel about the new Sierra Railway? What evidence do you have to support your claim? *They are excited; Interpretation based on this evidence: "we love riding trains and learning about them," "our grandparents live in Jamestown ... the trip will be much faster,"*
2. What are some challenges facing the construction of the Sierra Railway? *Obtaining right-of-way along the route, transporting the construction materials and people needed, dealing with the challenging terrain; Interpretation based on this evidence: "Our father told us train owners have to get permission to lay track. It's called right-of-way. Sometimes the railroad company has to pay to go through land. Sometimes the land owners give permission for free." "Nearby there are many pretty hills, the Stanislaus River, and creeks. The Sierra Railway will have to travel through these areas."*

3. What are some benefits that will result from the completion of the Sierra Railway? *Transportation of goods between communities, transportation of passengers between communities; Interpretation based on this evidence: "We'll be able to travel to see them by train instead of stagecoach. The trip will be much faster." "The train can transport the minerals extracted, or taken out, from the mines." "The train would bring the lumber here to Oakdale in the valley. Then people could buy it." "They travel from here to Yosemite and to other towns on stagecoach. Maybe the Sierra Railway will make their trip faster and more fun."*

### Predictive Questions:

1. Where else do you think the Sierra Railway will travel to? *Answers will vary.*
2. What do you think the Sierra Railway will transport? *Answers will vary.*
3. Do you think the fuel source of the steam locomotives will stay the same for many years? *Answers will vary.*

## Assessing the Outcomes

1. Explain to students they are going to use the text to individually respond to a few questions to demonstrate what they have learned. They will explain at least three events related to the Sierra Railway, define migration, and answer a question about how the Sierra Railway locomotives were originally powered.
2. Have students turn to "What I've Learned about The Rise of the Sierra Railway" in their student workbooks. Have them answer the questions using Ruth and Peter's Diary.
3. Once students have completed the assessment, have them put their pencils down and have a few students share their answers.
4. Collect the students' workbooks.
5. Explain to them that the next lesson on the Sierra Railway will challenge them to use a map to predict the route of the Sierra Railway and identify strategies to overcome difficult terrain or geographic features on the land.

## Student Workbook Questions:

### What I've Learned about The Rise of the Sierra Railway

In the spaces below, answer the three questions.

1. Use Ruth and Peter's diary to explain three events related to the Sierra Railway.

*(Answer: Student answers will vary. All answers should be directly from the informational text.)*

a. \_\_\_\_\_

b. \_\_\_\_\_

c. \_\_\_\_\_

2. Define the word migration.

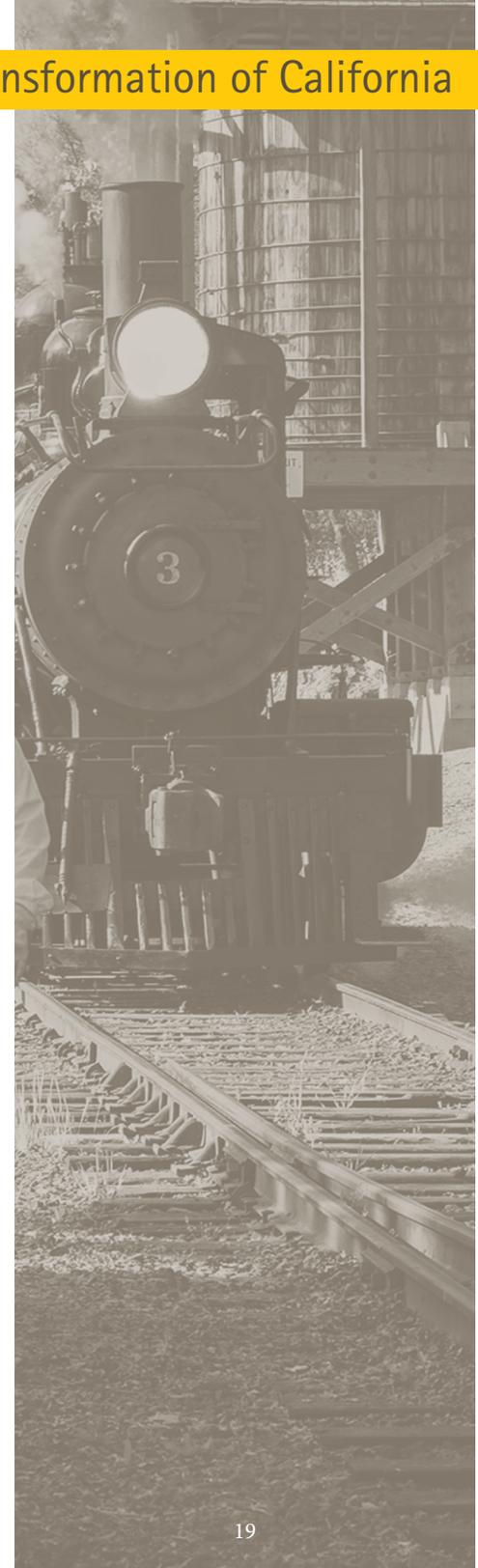
*(Answer: The physical movement of people from one area to another)*

\_\_\_\_\_

3. Describe how the Sierra Railway steam locomotives were powered (you may refer to the text).

*(Answer: The fuel for the locomotive is coal. When coal is burned, energy is transferred to different parts of the locomotive. Eventually the energy is transferred to the wheels to make them turn which makes the train move.)*

\_\_\_\_\_



# Lesson 2: Laying Track

## Subject Areas

History-Social Science, Mathematics, Science

## Advanced Preparation Time

30 minutes if students need to be taught how to read a topographic map

## Instructional Time

120 minutes

## Assessment Time

45 minutes

## Learning Outcomes

- Students will be able to defend the need for parallel rails to ensure the smooth movement of a train.
- Students will be able to identify the route the Sierra Railway had to travel as an engineering problem and describe at least two solutions.

## Key Vocabulary

**Constraint:** a limit or a restriction

**Engineering:** designing a solution to a problem or need

**Grade:** slope, measured in percent.

**Narrow gauge:** a set of tracks whose two rails are spaced less than the standard distance of 56.5 inches

**Parallel:** lines that are the same distance from each other everywhere and never cross

**Siding:** a short track that connects to a main line track, used to store rolling stock or enable trains on the same line to pass each other

**Standard gauge:** a set of tracks whose two rails are spaced the standard distance of 4 feet, 8.5 inches

**Switchback:** a path that makes a “Z” shape winding along a hillside

## Summary

Students read another entry in Ruth and Peter’s diary to learn that laying track is challenging due to geography, right-of-way politics, other constraints, and requirements for safely transporting freight and people. These challenges have to be met, however, in order to support the growth of towns and local economies. Working in small groups, students study topographic maps of the area and assess both constraints and requirements of transporting goods and people to and from specific places. Students predict the path of the Sierra Railway and in the process learn about various engineering strategies used by railroad companies to navigate different terrains. They also learn that a train’s track has to be made of two rails that run parallel to each other. The Sierra Railway’s engineering decisions and chosen routes affected accessibility and transport between industries and populations, thereby affecting the pattern of growth and development in the area.

## Materials

- Digital projector, computer, and screen if projecting the reading
- Pencils (one per student; consumable item)
- Pens: wet erase pens (one per pair of students)
- Projectable Lesson 2 reading if applicable
- Rags or towels: small (for erasing transparency) (one per pair of students)
- Rulers: metric, 30 cm (one per pair of students)
- Student workbook (one per student; from Lesson 1; consumable item)
- Transparency sheet or sheet protector (three per pair of students; consumable item)
- Video of train climbing switchbacks (<https://youtube/a86Mdkd-WrA> or [https://youtu.be/3ASKDx\\_QSWE](https://youtu.be/3ASKDx_QSWE); see footnotes in lesson plan)
- Word wall cards: constraint, engineering, grade, narrow gauge, parallel, siding, standard gauge, switchback

## Images (projectable images are in the Appendix)

- Sonora 1898 Answer Key
- Jackson 1902 Answer Key

(Other topographic maps are in the Student Workbook)

## Advanced Preparation

1. Determine if students will need instruction on reading topographic maps and interpreting contour lines. Teach them this skill if necessary.

## Prerequisite Knowledge

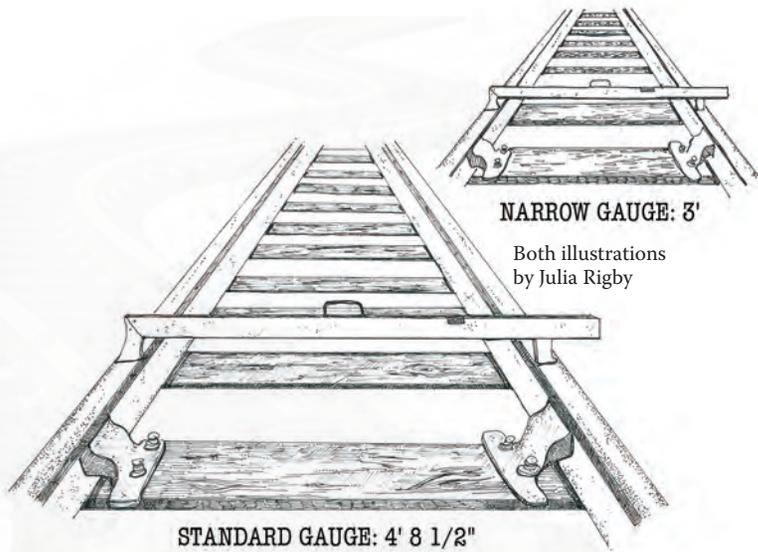
Students should know how to read a topographic map and interpret contour lines. (For teaching suggestions, see Resources for Teachers in the Unit Material.)

Students should be able to draw parallel lines using a ruler.

## Background

The Sierra Railway route traveled between the valley and the foothills of the Sierra Nevada, above rivers, through canyons, over mountains, and around many turns. In 1926, the Sierra Railway was running on 88 miles of standard gauge track. Standard gauge means that the distance between the two rails, which have to be parallel in order to prevent cars from derailing, is four feet eight and one-half inches. Narrow gauge tracks, which have less distance between the two rails of the track, were sometimes used in the construction of difficult mountain terrain. They were less expensive to build and the narrow cars were easier to maneuver around curves and up grades (slope).

When the Sierra Railway was incorporated, construction specifics were laid out. Bullock already had experience with three railroads, and he was concerned about building quality track. Sierra Railway contracted with the West Coast Construction Company and construction planning began. The construction workers had to know how to measure distance and apply mathematics.



Both illustrations  
by Julia Rigby

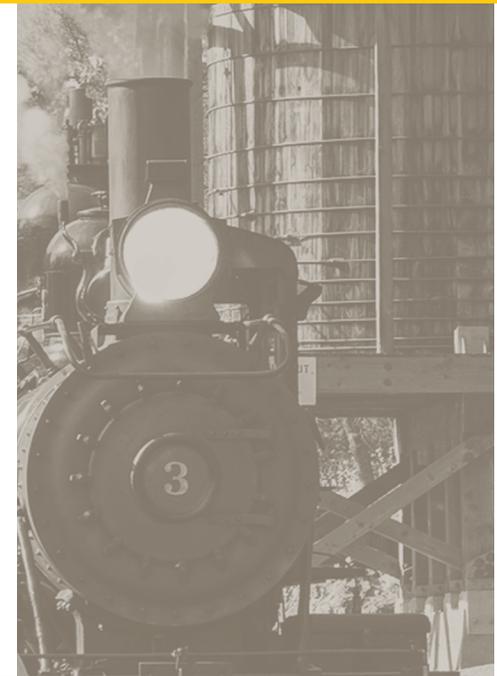
The railroad was to be built with steel rail weighing forty pounds to the yard with good quality angle plates and four nuts and bolts at each joint. It was to include switches at all sidings and rail braces on the curves. Ties were to be either of oak or redwood, 3200 ties to the mile, spaced 18.8 inches apart at the centerlines with each tie to be 8 feet long and 8 inches wide by 6 inches deep, with four spikes set per tie . . . The contracts further stipulated the specifications for all bridges and water crossings. Grade of the roadbed was to be 30 inches above the surrounding land except in cuts, with the road bed 12 feet wide on straight sections and 14 feet wide in curves. Ballasting [gravel or coarse stone used to form the bed of a railroad track or road] was to be of the natural soil along the line.<sup>1</sup>

Laying track was a multiple stage process that involved careful engineering as well as negotiation skills. Prior to laying track, surveys would be conducted to determine the best path through the terrain. A route initially selected for efficiency could later be dismissed because of safety concerns for the trains, freight, or passengers. Derailments needed to be avoided and locomotives needed to be able to climb steep grades. Once the survey was

complete, right-of-way discussions took place with landowners. Some landowners were willing to accept free passenger transport, or another advantage, in exchange for allowing the track to cross their land. Others would only accept a cash payment. Farmers or ranchers might oppose fences bisecting their land and reducing pasture area. The person in charge of obtaining right-of-way had to negotiate with or convince the landowners along the route to allow the track to be laid through their property; if they did not succeed, the track had to be rerouted. At one point the Sierra Railway was having such a hard time obtaining right-of-way on the line to Angels Camp, that Bullock proposed building an aerial tram that would bypass (and therefore not serve) many of the mines along the route! This was most likely a bluff to push the landowners to give right-of-way to the railroad.

The challenges posed by the terrain along the proposed route had to be solved by an engineer who understood various constraints including the locomotive's power, stability, and safety. Cooperstown's elevation is 265 feet (84 meters) and Chinese Camp is at 1,273 feet (388 meters). The 18 miles of track laid between the two towns included a gradual climb up Dry Creek Canyon that was a significant challenge during construction and operation.

The terrain was not the only difficulty encountered. Rain, snow, and hail made rails slippery, creating problems for the locomotives. Other natural elements also caused logistical problems. Grasshoppers were attracted to the sun-warmed rails, and the insects, with their variable body temperature, would sun themselves on the rails. In one rail trip, "slippage had resulted from a scourge of grasshoppers whose crushed bodies on the 3% canyon rails made them [the rails] slick as grease."<sup>2</sup>



Los Angeles Herald  
Number 226, 14 May 1899

## A Big Blast

Jamestown, Cal., May 13—Something new in railroad construction was inaugurated today by the Sierra Railway company of California at the cut-off on the road near Chinese camp, where the company is using the largest steam shovel in the west. The occasion was the simultaneous discharge of 10,000 pounds of giant and Judson powder in a best of blasts. The explosion was a perfect success, dislodging in the neighborhood of 5000 cubic yards of rock and earth. A special train brought visitors from Oakdale and other points of the road to witness the unusual sight. Huge rocks were blown into the air, and some of them fell half a mile from the explosion.

—Associated Press.

California Digital Newspaper Collection, Center for Bibliographic Studies and Research, University of California, Riverside, <http://cdnc.ucr.edu>.

<sup>1</sup> Connerly, "When the Railroad Came to Tuolumne," 1260.

<sup>2</sup> Deane, *Sierra Railway*, 22.

# Lesson 2: Laying Track

## Standards Connections

### California Common Core State Standards Mathematics

- Grade 4, Geometry: Draw and identify lines and angles, and classify shapes by properties of their lines and angles.
  - Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures.

### History-Social Science Standards

- 4.4. Students explain how California became an agricultural and industrial power, tracing the transformation of the California economy and its political and cultural development since the 1850s.
  - 4.4.4. Describe rapid American immigration, internal migration, settlement, and the growth of towns and cities (e.g., Los Angeles).

### Next Generation Science Standards

- 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

Between Jamestown and Tuttletown, Table Mountain created a formidable obstacle for the track to surmount.

Table Mountain is an ancient lava flow forty miles long with a flat top averaging over half a mile in width. Its sides, where it intersects the Mother Lode, are perpendicular walls of solid basalt five to eight hundred feet high. The existing railroad cut, through the lowest pass of this basalt table, was 40 feet deep and 15 feet wide. Although the bottom of the cut, at 1,710 feet elevation, was only some 300 feet above Jamestown on the one side and Tuttletown on the other, the climb to it was so short and steep it was called a hurdle. To reduce these grades, widen the cut and reduce curvature to 29 degrees, still the heaviest [curviest] on the Sierra railroad, took a gang of men a month working with powder, hand shovels and a steam-piston drilling machine on a tripod.<sup>3</sup>

Probably the most difficult terrain to navigate lay between Tuttletown and Angels Camp. Chief Engineer William Newell “and his transitmen climbed up and down all around the Stanislaus canyon staking out the snakiest railroad ever to be built.”<sup>4</sup>



**Table Mountain Cut**

Photo courtesy of Calaveras County Historical Society

The length of the switchbacks accommodated “a three car and caboose freight train...although it was expected that the average consist, with heavy loads such as ores and mine timbers, would be two cars and a caboose on these canyon cliffs.”<sup>5</sup> The Sierra Railway purchased a special locomotive, a Shay that was a geared locomotive, for the Angels Camp line. Special short passenger / baggage cars, that could handle the curves, were built for the line as well. A woman who rode on the Angels Camp line as a child

<sup>3</sup> Deane, *Sierra Railway*, 46.

<sup>4</sup> *Ibid.*, 63.



**Switchback**

Photo courtesy of Tuolumne County Historical Society

Newell decided to use “switchbacks on either side of the canyon with grades on which a train could safely scale the cliffs.”<sup>5</sup> This was “called preposterous and scoffed at as an utter impossibility by many contemporary railroad engineers.” (*ibid.*)

On the Tuolumne side of the canyon the roadbed was to descend by a double switchback called the McArdle Switch... Dropping down Soldier’s Gulch and crossing Joe William’s cow corral on the edge of the steep ravine, the switchbacks, tangents and curves wound downward to the level of the almost completed railroad trestle across the river, a seven hundred foot drop in four miles of track with grades up to 4.15 per cent and 27 to 28 degree curves. Climbing from the river on the Calaveras County side, only one switchback was to be used, although a longer one, to be called the Pendola Switch. Eight miles of track with grades equaling the previous ones were required to reach that crest, 660 feet above the river.<sup>6</sup>

described it as “very scary. The tracks went from Angels Camp to Carson Hill, then down into the Stanislaus River Canyon and up the other side near Tuttletown and then into Jamestown. To cross the Stanislaus River Canyon the track route went down some

<sup>5</sup> *Ibid.*, 67.

<sup>6</sup> *Ibid.*, 67–68.

<sup>7</sup> *Ibid.*, 70.

switchbacks, backing up then going forward several times, then around some very tight turns until we were out of the canyon.”<sup>8</sup>

The bridge that was built across the Stanislaus River by the California Bridge and Construction Company of San Francisco “was a 140-foot wood and steel Howe deck truss bridge with wood trestle approach sections for a total length of nearly 600 feet.”<sup>9</sup> In addition to the bridge that was built across the Stanislaus River, “several other trestles over 300-foot length and 70-foot height were required to cross the numerous ravines and side creeks on both sides of the river.”<sup>10</sup>

## Procedures

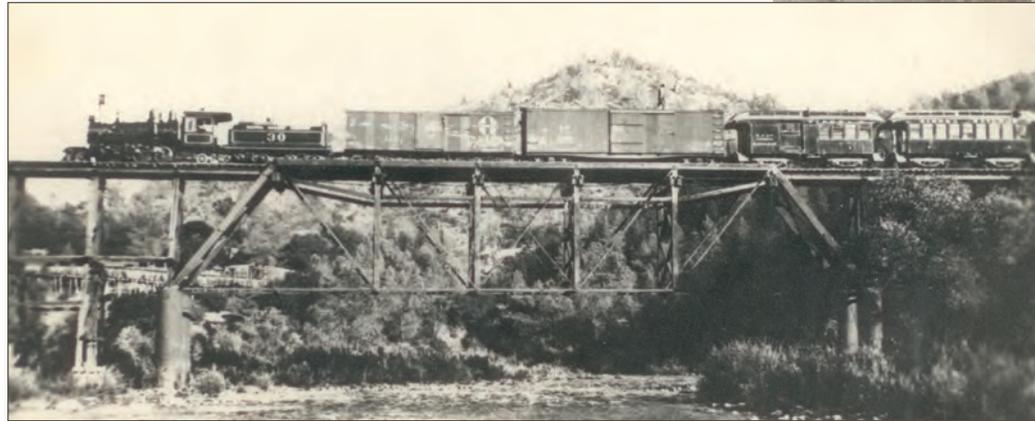
### Introductory Information

1. Tell students today they are going to read the next passage from Peter and Ruth’s diary about the Sierra Railway. Explain that the siblings were curious about the track and that the class will explore the topic.
2. Distribute a student workbook to each student.
3. Have them turn to page 10 to the section entitled, “Laying Track: Part One.”
4. Give students time to read the story. (Note: The story may be projected and read out loud by the teacher or students who are strong readers).
5. Ask a few student volunteers to share what they learned from Peter and Ruth and what they wanted to know. (*They wanted to figure out the route the train would travel between Oakland and Jamestown and solutions engineers would use to deal with creeks and hills.*)
6. Give them five minutes to examine the topographic map from 1947 that shows the area between Oakdale and Jamestown. Tell them to consider the topography between these two cities and think about the engineering challenges that may arise when laying track and how they may be resolved. Optional: Read to students

<sup>8</sup> Rasmussen, “The Good Old Days,” 1455.

<sup>9</sup> Connery, “Sierra Railway’s Angels Branch Part 1,” 1874.

<sup>10</sup> *Ibid.*, 1876.



**Howe Deck Truss Bridge**  
Photo courtesy of Calaveras County Historical Society

the background information descriptions of geographic challenges on the Sierra Railway route.

7. After five minutes, have a few student pairs share their thoughts about the challenges—rivers, mountains, canyons, the absence of a straight route. Ask different groups to share how they think an engineer might overcome those challenges (*building bridges over rivers; going around or over mountains and hills, blasting tunnels through them; avoiding canyons or building bridges over them, laying track that curves as necessary*).
8. Tell them they are now going to use detailed topographic maps along the route to work with a partner to lay the Sierra Railway track.

### Presenting the New Material/Practicing the New Material: Step-by-Step Procedures

1. Assign students to work with a partner. Give each pair three transparencies or sheet protectors, a wet erase pen, a rag or towel, and a ruler.
2. Tell students to turn to pages 11 through 13 in their student workbook, titled “Oakdale to Jamestown Topographic Maps: Engineering Challenge” that contain detailed Oakdale to Jamestown topographic maps.
3. Explain to students that for the next thirty minutes they will be the Sierra Railway’s Engineers in Charge of Location and Surveys. They are to work with their partners to survey and locate track,

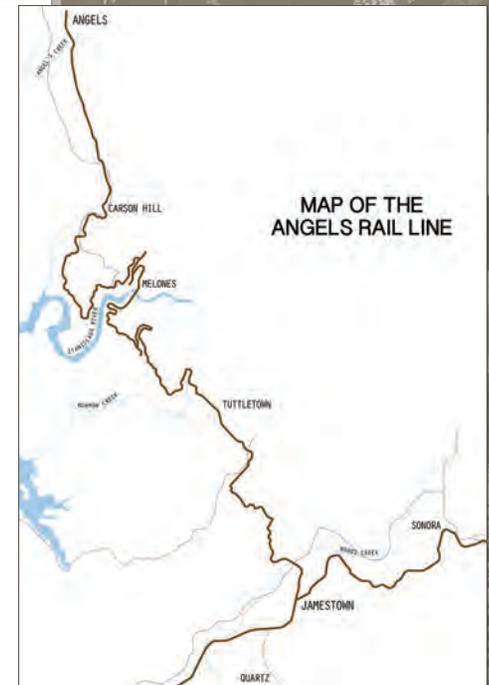


Illustration by Amy Hay

which means to figure out where the track will be laid, from Oakdale to Jamestown. Restrictions and limitations, or constraints, include: passengers and freight need to be safe and comfortable on the ride, materials such as wood and spikes and workers need to be transported on the tracks that have already been completed or by stagecoach to the construction site, in the 1900s tools for blasting/cutting were less sophisticated than they are now, bridges need to handle the weight of the train with passengers and freight, stagecoaches need to be able to bring passengers and freight to the train depots at various stops along the route to load and unload, and the train cannot derail on turns.

To complete this activity, students will lay the transparency or sheet protector over one of the students' topographic maps in the workbook. They will use the pen and ruler to locate the track where they think it should go. At challenging spots (e.g., a river), they should describe and draw on the transparency or sheet protector how the challenge should be overcome (e.g., bridge). Remind students that trains have wheels on either side of them, like a car, and that they should consider this when drawing the track, which consists of two parallel rails (you may want to allow the students to figure this out on their own instead of telling them). Explain to them that they will be sharing their routes and engineering solutions with their classmates.

4. Once the majority of students have completed the activity or thirty minutes have passed, combine three pairs of two students for a total of six students in a group. Explain to them that they will have ten minutes to share their routes and engineering solutions with their groupmates. They should be able to explain why they chose each specific solution for each specific challenge to their fellow engineers. Each group of six students will also choose one engineering solution to share with their classmates. Remind them they have ten minutes to share their ideas with each other and to select one engineering challenge to share with the class.

5. After ten minutes, get students' attention and have each group share one engineering solution. Ask a few students to describe why parallel rails are necessary for the smooth movement of a train. (*Rails that deviate from parallel will cause a train to derail because the wheels are fixed at a specific width.*)

6. Tell students they are now going to return to Ruth and Peter's diary and read, "Laying Track: Part 2," on pages 14 – 22, to find out the solutions the Sierra Railway's engineers came up with.

7. After students have finished reading, ask them:

- "Which of their solutions are similar to your solutions?" (Answers will vary.)
- "Which were different?" (Answers will vary.)
- "Did any of the solutions they describe surprise you?" (Answers will vary.)
- "Describe new solutions you learned." (Answers will vary.)

8. Show them a video of a train traveling on a switchback.<sup>11</sup>

### Assessing the Outcomes

1. Tell students that the Sierra Railway's Angels Camp Branch had such difficult terrain that when work first began on it in 1898, the construction company quit. This is when a young civil engineer, William H. Newell, was hired as the company's Engineer in Charge of Locations and Surveys. In October 1898 he took over as Chief Engineer. The Angels Camp Branch was not completed until 1902 because focus was shifted to extending the Sierra Railway line to the east towards Carters/Summersville/Tuolumne City.

2. Explain to students that individually they are going to examine the topographic maps between Jamestown and Angels Camp. They have about 40 minutes to complete their work. They are to focus on two geographic challenges and describe two solutions in their student workbook.

3. Also in their workbook they will defend the need for parallel rails to allow the smooth movement of a train.

4. Have students turn to pages 23 through 27, read the information, study the topographic maps, and complete the assessment.

<sup>11</sup> Bigsteam57, "Steam Train on the Devil's Nose Switchback, Ecuador," <https://youtube/a86Mdkd-WrA>.

Tsgmultimedia, "N Scale how a Switchback Works," [https://youtu.be/3ASKDx\\_QSWE](https://youtu.be/3ASKDx_QSWE).

5. Once students have completed their assessments, have them put their pencils down and have a few students share their answers.
6. Collect the students' workbooks.
7. Show students the chosen path between Jamestown and Angels Camp. (Projectable images are in the Appendix.)
  - Sonora 1898 Answer Key
  - Jackson 1902 Answer Key
8. Show students the images of Newell's engineering solutions along the route.
9. Explain to them that the next lesson on the Sierra Railway will help them understand the science behind a steam locomotive.

## Student Workbook Questions:

### What I've Learned about Laying Track

Geographic Challenges in the Jamestown – Angels Camp Sierra Railway Branch

Instructions: Using the topographical maps that show Jamestown to Angels Camp, describe two challenges the Sierra Railway will face and offer a solution for each. Use the information learned from class discussion and Ruth and Peter's diary.

1. Geographic challenge #1: *(answers will vary)*

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Engineering solution: *(answers will vary)*

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2. Geographic challenge #2: *(answers will vary)*

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Engineering solution: *(answers will vary)*

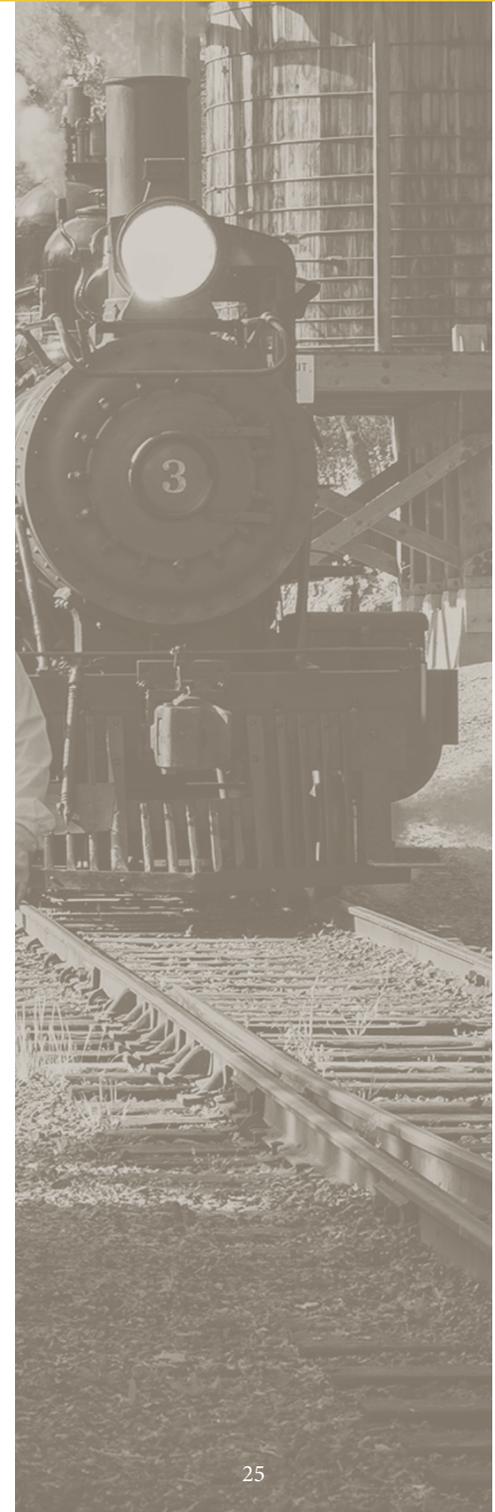
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Use the outline below to defend the need for parallel rails to ensure the smooth movement of a train. Provide a written reason and draw a diagram to explain or support your evidence.

Claim Statement: Parallel rails are needed to ensure the smooth movement of a train.

Reason 1: *(the wheels on a train are at a fixed width, and this width needs to match the distance between the two rails that make up the track. If the distance between the rails changes along the route, the wheels can't adjust to the new width, and the train car will derail. Therefore, the rails must be parallel to each other along the whole line.)*

Drawing: *(drawings will vary)*



# Lesson 3: The Science Behind a Steam Locomotive

## Subject Areas

History-Social Science, Mathematics, Science

## Advanced Preparation Time

60 minutes

## Instructional Time

Lesson Elements: Engage, Explore, Explain: 75 minutes

Extend: 45 minutes

Evaluate/Assessment: 30 minutes

## Learning Outcomes

- Students will be able to provide at least two examples in which energy is transferred from place to place by sound, light, heat, or electrical currents.
- Students will be able to diagram one transfer of energy in a steam locomotive.

## Key Vocabulary

**Conduction:** the transfer of heat through physical contact between components in a system.

**Convection:** the transfer of heat through the movement of a medium, such as air or water.

**Energy:** a measurement of how much work a system can do

**Kinetic energy:** energy that results in an object's motion

**Potential energy:** stored energy due to the position of components relative to each other in one system

**Transfer:** movement from one place to another

## Summary

Students explore the transfer of energy from place to place, and the conversion of energy from one type to another, by participating in various hands-on activities with materials that are familiar to them. These energy concepts affect the structure and function of steam locomotives. This lesson also helps students recognize that trains not only transport ecosystem goods, but also rely on them as a source of fuel for energy. Without access to, or availability of, these goods, the Sierra Railway could not have been built. The course of history in the Sierra Nevada foothills would have been different as a result.

## Materials

### General Lesson Supplies

- Container: plastic, shoebox-sized (one per class)
- Cups: foam or heat-safe (five per class; have extras in case they break)
- Digital projector, computer, and screen if projecting the reading
- Food coloring: blue (one small bottle per class; consumable item but one small bottle is sufficient for multiple classes)
- Food coloring: red (one small per class; consumable item but one small bottle is sufficient for multiple classes)
- Freezer (to manually make ice cubes the night before the lesson) (one per class)
- Ice cube dyed with blue food coloring (one per class; consumable item)
- Ice cube trays (enough to make one blue-dyed ice cube per class) (make the night before the lesson)
- Pencils (one per student; consumable item)
- Pipette or dropper (one per class)
- Projectable Lesson 3 reading if applicable
- Projectable images of locomotive (see Appendix)

- Student workbook (one per student; from Lesson 1; consumable item)
- Video: “032 — How a Steam Locomotive Works:” <https://youtu.be/wZSoMxTb1ZM>
- Water: hot (enough to fill one foam/paper cup per class)
- Water: room temperature (enough to fill shoebox container three-quarters full per class)
- Worksheets (one per student; consumable item; see Appendix)
- Word wall cards: conduction, convection, energy, kinetic energy, potential energy, transfer  
(see Explore Station Descriptions for material set up)

### Station Supplies: In Addition to General Lesson Supplies

Station cards: printed and laminated (one per station per class)  
*See Appendix for reproducible Station Cards.*

#### Station 1

Balloon: standard round (one per class; have extras in case it pops)  
Electrical outlet (one per class)  
Music: heavy bass (one song)  
Radio/CD player (one per class)  
Ruler: metric (one per class)

#### Station 2

Bag: plastic, sandwich-sized resealable (one per class)  
Baking pan (one per class)  
Mug or empty soup can (one per class)  
Plastic wrap: 30 cm. by 30 cm piece, or large balloon (one per class)  
Rice: uncooked (two tablespoons per class)  
Rubber band (one per class; have extras in case it breaks)

## Station 3

Flashlight (one per class)

Ruler: metric (one per class)

Thermometer: Celsius (one per class)

## Station 4

Outside access

Thermometer: Celsius (one per class)

## Station 5

Containers: plastic, large enough to hold one ice cube for each student in the class (two per class)

(label one “new” and the other “used”)

Ice cube (one per student; consumable item)

Ice cube trays (enough to make at least one ice cube per student) (make the night before the lesson)

Paper towels or reusable towel (one roll or towel per class)

## Station 6

Electrical outlet (one per class)

Heating pad (one per class)

Ruler: metric (one per class)

## Station 7

Copper wire or insulated wire with stripped ends: 15 cm (three pieces per class; have extras)

D-size battery (one per class)

D-size battery holder (one per class)

Knife switch: single pole single throw, small (e.g., [http://www.novatech-usa.com/Products/Electricity/KSW001-K?gclid=CJOZ9\\_v\\_l8cCFVc7gQodnL0O\\_w](http://www.novatech-usa.com/Products/Electricity/KSW001-K?gclid=CJOZ9_v_l8cCFVc7gQodnL0O_w)) (one per class)

Light bulb holder: miniature (one per class)

Light bulb: miniature (that fits into light bulb holder) (e.g., Eiko #48) (one per class)

## Station 8

Electrical outlet (one per class)

Light: small, portable, desk-light-style (one per class)

## Station 9

Flat surface: large (e.g., classroom floor)

Marble: large (one per class)

Marbles: small (ten per class)

Ruler: metric (one per class)

## Station 10

Dominoes (ten per class)

Flat surface: large (e.g., classroom floor)

## Station 11

Drum (if not available, create your own drum using instructions in Station 2) (one per class)

Drumstick (if not available, substitutions can be made) (one per class)

## Station 12

Container: plastic, 8 oz (one per class)

Tray: plastic (one per class)

Tuning fork (one per class)

Water: room temperature (enough to fill an 8 oz container)

## Station 13

Flat surface: small (e.g., a desk or table top) (one per class)

Wind-up toy: small (one per class)

## Station 14

Bicycle pump: manual with air tube attachment intact (one per class)

## Standards Connections

### *Next Generation Science Standards*

- 4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electrical currents.

### **Environmental Principles and Concepts**

- Principle 1: The continuation and health of individual human lives and of human communities and societies depend on the health of the natural systems that provide essential goods and ecosystem services.
- Concept a. Students need to know that the goods produced by natural systems are essential to human life and to the functioning of our economies and cultures.

# Lesson 3# The Science Behind a Steam Locomotive

## Advanced Preparation

1. View the video “032 — How a Steam Locomotive Works”  
<https://youtu.be/wZSoMxTb1ZM>
2. Well before the lesson will be taught: gather all the materials necessary for the “Explore” stations and the “Extend” demonstration.
3. On the night before the lesson: make at least one blue-food-coloring-dyed ice cube per class. Also make multiple trays of ice cubes for students (one ice cube per student) for Station 5.
4. Prior to lesson: print and cut the Station Cards. Laminating them will ensure they last longer. Prepare and set up all the Stations. See the Station descriptions for details. *See Appendix for reproducible Station Cards.*
5. During lesson: heat water for the convection demonstration. The water should be almost boiling. You may want to wait to heat this water until students are almost done with “Explain” so the water is still hot enough for the demonstration.
6. Copy one Explore Stations Worksheet for each student (see Appendix)

## Explore Station Descriptions

### Station 1: Energy Transfer through Sound — Balloon and Music

Materials: inflated balloon, radio/CD player, electrical outlet, music with heavy bass, station card, metric ruler

Set up: Plug in radio/CD player and set so when students push “play” or turn on the radio, music with heavy bass plays. Inflated balloon with tied end should be near radio.

### Station 2: Energy Transfer through Sound — Rice and Baking Pan

Materials: resealable bag, no more than 2 tablespoons of uncooked rice, baking pan, mug or empty soup can, rubber band, balloon or plastic wrap, station card

Set up: To make the “drum:” if using a balloon, cut off the open tip and stretch it over the open end of the mug/can. Secure the edges with a rubber band. If using plastic wrap, place the wrap over the open end of the mug/can. Secure the edges with a rubber band. Measure no more than 2 tablespoons of uncooked rice and place into resealable bag. Place baking pan near other materials.

### Station 3: Energy Transfer through Radiation (Light) — Flashlight

Materials: °C thermometer, flashlight, metric ruler, station card

Set up: None

### Station 4: Energy Transfer through Radiation (Light) — Sun

Materials: °C thermometer, access to outside, station card

Set up: None

### Station 5: Energy Transfer through Heating — Ice Cube

Materials: two containers that each can hold enough ice cubes for each student in the class, label one container “new” and the other “used,” paper towels or reusable towel, ice cubes (1/student), station card

Set up: Place the ice cubes (1/student) in the “new” container, set the empty “used” container near the “new” container.

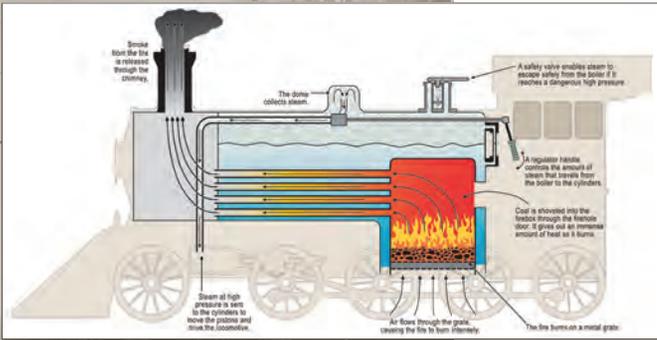
### Station 6: Energy Transfer through Heating — Heating Pad

Materials: heating pad, electrical outlet, metric ruler, station card

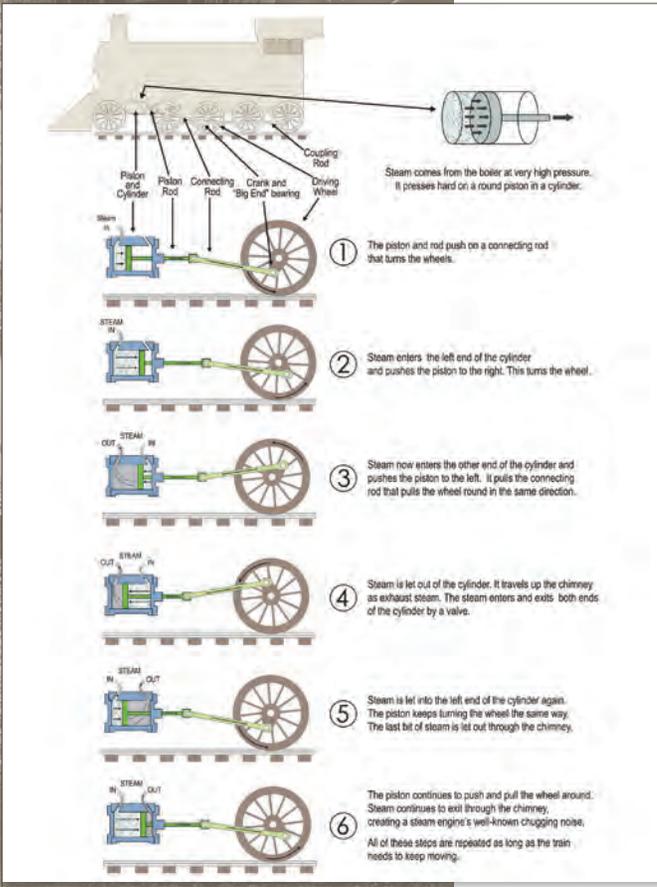
Set up: Plug the heating pad into the electrical outlet and set it to “low.” Place the metric ruler next to the heating pad.

### Station 7: Energy Transfer through Electric Currents — Series Circuit

Materials: one D-size battery, one D-size battery holder, one miniature light bulb holder, one miniature light bulb (that fits into light bulb holder), one small single pole single throw knife switch,



Both illustrations by Amy Hay



three pieces of 15 cm copper wire or insulated wire with stripped ends, station card

Set up: Create a circuit using the materials. Leave the switch open.

### **Station 8: Energy Transfer through Electric Currents — Portable Light**

Materials: electrical outlet, small portable / desk light, station card

Set up: None

### **Station 9: Kinetic (Movement) Energy to Kinetic Energy — Marbles**

Materials: one large marble, 10 small marbles, one metric ruler, large flat surface (classroom floor is sufficient)

Set up: None

### **Station 10: Kinetic (Movement) Energy to Kinetic Energy — Dominoes**

Materials: 10 dominoes, smooth flat surface (classroom floor is sufficient if dominoes can be balanced upright)

Set up: None

### **Station 11: Conversion of Energy: Kinetic Energy to Transfer through Sound — Drum**

Materials: one drumstick, one small drum. If these items are not available, substitutions may be made, such as: a wooden spoon and a baking pan, a fork and a ceramic mug, a chopstick and a drum made out of a balloon pulled taut over a mug (see Station 2 for directions to make drum)

Set up: None

### **Station 12: Conversion of Energy: Transfer through Sound to Kinetic Energy — Tuning Fork**

Materials: one tuning fork, one small plastic container (8 oz.), one plastic tray, one quart of water

Set up: Place the small plastic container on top of the plastic tray. Pour enough water into the small plastic container to almost fill it. Place the tuning fork outside of the tray. Place the remaining water elsewhere (students may be told that if a refill is needed, they have to ask you for it).

### **Station 13: Conversion of Energy: Elastic Potential Energy to Kinetic Energy — Wind-up Toy**

Materials: one small wind-up toy, smooth flat surface (so the toy can function)

Set up: None

### **Station 14: Conversion of Energy: Kinetic Energy to Transfer through Sound and Heat — Bicycle Pump**

Materials: one manual bicycle pump with air tube attachment intact

Set up: None



Sierra Railway No. 3 Locomotive, 2016  
Photo courtesy of Kathy Syverson

## **Prerequisite Knowledge**

Students need to know how to use a metric ruler.

Students need to know how to read a thermometer in Celsius.

## **Background**

A steam locomotive operates through a series of transfers and conversions of energy. Energy is not matter, it is not power, and it is not a force. Energy is a measurement of how much work a system can do or how much change can occur in a system.<sup>1</sup> Within a given system, energy cannot be lost or gained; rather, it is transferred between the items in the system, and/or it is converted from one type of energy to another.

The idea that there are different forms of energy, such as thermal energy, mechanical energy, and chemical energy, is misleading, as it implies that the nature of the energy in each of these manifestations is distinct when in fact they all are

<sup>1</sup> Daehler, Folsom, and Shinohara, *Making Sense of Science*, 1-14 — 1-18.

## Lesson 3: The Science Behind a Steam Locomotive

ultimately, at the atomic scale, some mixture of kinetic energy, stored energy, and radiation. It is likewise misleading to call sound or light a form of energy; they are phenomena that, among their other properties, transfer energy from place to place and between objects.<sup>2</sup>

In a steam engine, such as a Sierra Railway locomotive, the fuel source could be wood, coal, or oil. This fuel is combusted, or burned. The difference in temperature between the burning fuel and the gas (air) around it causes heat to move from the hotter item to the cooler item. Heating transfers energy from the burning fuel to the gas. In this case, the gas warms up and the fuel cools. The heated gas travels through fire tubes that pass through a boiler filled with water. Once again, a temperature difference is present between the heated gas in the fire tubes and the water in the boiler surrounding the fire tubes. Energy is transferred via conductive heating from the hot gas, to the metallic fire tubes, to the surrounding water. The heat from the fire tubes causes the water to boil, which creates steam.

The steam (gas) is collected in the steam dome. From the steam dome the gas is forced down a large pipe to two cylinders, one on each side of the locomotive. When the steam is forced into the cylinders, the gas particles collide with the solid particles in the piston. A transfer of energy occurs from the gas to the piston. The piston now has kinetic energy so it moves. Because the piston is attached to the wheel of the train by way of driving rods, the kinetic energy is transferred to the rod and thus the wheel, thereby causing the wheel to turn.

Once the rod has moved in one direction due to the transfer of energy from the gas to the piston to the rod, gas (steam) is then pushed into the other side of the cylinder, moving the piston and therefore the rod back to its starting position and causing further rotation of the wheel. The steam released out from the cylinders travels upwards through the smokebox and is forcibly released out the chimney. At this point some of the energy is transferred through sound in a steam locomotive's characteristic "choo, choo" sound.

<sup>2</sup> National Research Council, *A Framework for K-12 Science Education*, 122.

## Procedures

### *Introductory Information*

#### **Engage**

1. Explain to students that today they are going to participate in hands-on activities that will help them understand a science concept that is essential in the functioning of a steam locomotive. Without this science concept, there would not have been a Sierra Railway story to tell. In fact, without this, no living thing on Earth would be able to do anything. Even machines would not be able to get any work done.
2. Have students turn to a neighbor and guess what this science concept might be. Have a few volunteers share. (Accept any answer)
3. Distribute a student workbook to each student.
4. Have them turn to page 28 to the section entitled, "The Science behind a Steam Locomotive: Part One."
5. Give students time to read the story. (Note: The story may be projected and read out loud by the teacher or by students who are strong readers).
6. Explain to students that they will explore energy and its movement from one thing to another so they can better understand what Ruth and Peter learned.

### ***Presenting the New Material/Practicing the New Material: Step-by-Step Procedures***

*See Appendix for reproducible Student Worksheets.*

#### **Explore**

1. Tell students they will visit fourteen different stations. At each station they are to read the station card, do the activity, and then write their observations on their worksheets. (Note: If time, space, or materials are not available to complete fourteen stations, choose at least seven of them for students to complete. Alternatively, seven can be completed each day for two days.)
2. Show students where the fourteen stations are.

3. Demonstrate the tools at the various stations (as needed for your students; see station descriptions to determine which materials to demonstrate) so students know how to use them (but not how to do the activity). For instance, hit a tuning fork against a hard surface to show students how to produce sound.

4. Divide students into groups, and give each a role within the group, by counting off students 1A – 9A, then 1B – 9B, 1C – 9C, and 1D – 9D (as necessary depending on the number of students in the group). All the 1s will work together, the 2s, and so on. Each group will have students A – D as well.

5. If necessary, assign roles for each person in the group and write it on the board. For instance, “The As will read the station card. The Bs will do the experiment first. The Cs will guide the discussion to fill in the worksheet at each station. The Ds will put the station back neatly so it is ready for the next group.

6. Tell the A students to come up to you and get a worksheet for each person in the group.

7. Explain that in Station 4 they are going to document the temperature outside by reading the degrees Celsius on a thermometer. Show students the thermometer and tell them the room temperature in Celsius. Have them write this number down on their worksheet for Station 4. Step outside and place the thermometer in a sunny spot. Prop the door open so students can walk in and out for this station and you can monitor them.

8. Tell students they will have approximately two to three minutes at each station. When you tell them to, they should rotate clockwise (e.g., Station 1 to 2, 2 to 3, etc. and 9 to 1). (Since there may be more stations than groups, you may choose to let students flow freely from station to station as long as they choose one that is empty.)

9. Tell them that at the end of the activity, each group will share their observations and explanations for the station where they started. They should designate one person to do this (or teacher can assign person C).

10. Assign Group 1 to Station 1, Group 2 to Station 2, and so on. Tell students they may start working at their first assigned station,

which will also be the one they share at the end of the Explore portion of the lesson.

11. While students are working, walk around the room interacting with students, posing questions, or helping students with materials. If they share misinformation, encourage them to redo the experiment or use prompting questions to guide them. Do not give any answers or content to them as they are discovering it on their own. Possible questions:

What happened?

Why do you think it happened?

Do you think something was transferred between the objects?

What happened to the energy in this system?

Did this object have to touch that one for something to happen?

If it didn't have to touch the object, how do you think that works?

12. Keep track of the two to three minute rotations and help students find their next stations.

13. Once students have visited all fourteen stations, have them return to the station where they started (i.e., Group 1 at Station 1). Tell them to decide what they would like to share about their observations and explanations of their first station. Encourage them to use information they learned from other stations to help inform what they observed at their first station. They should not describe the activity, but rather what they learned from it and/or observed as it relates to energy. Give them five minutes to prepare what they will share.

## **Explain**

1. Have students return to their seats, or, if appropriate, have them sit at the station where they started (i.e., Group 1 at Station 1).

2. Remind students that when other classmates are sharing, they need to be quiet listeners.

3. Starting with Station 1, ask Group 1 to share their observations and explanations. Ask the rest of the class if they agree, disagree, had a different observation, or have other ideas. Help students arrive to information that supports the activities they did.



## Lesson 3: The Science Behind a Steam Locomotive

Continue with the rest of the groups. For the stations that did not have a designated group, ask for volunteers to share their observations regarding energy transfers.

4. Based on the observations students shared, fill in any missing or additional information, or correct misconceptions as necessary. Students should understand that energy can be transferred from place to place by sound, light, heat, and electrical currents. Energy can also be converted from one type to another. Labeling the various types (e.g., elastic potential energy, kinetic energy) is beyond the scope of the science performance expectation at grade four and therefore is optional.

### Extend

1. Ask students what they think all of these activities about energy have to do with the Sierra Railway and steam locomotives. Have a few students share their ideas. (*Steam locomotives require energy to move. Energy is transferred place to place in a steam locomotive. The fuel source that begins the transfer of energy in the locomotive's system is coal or oil.*)

2. Distribute a student workbook to each student.

3. Have them turn to page 30 to the section entitled, “The Science behind a Steam Locomotive: Part 2”

4. Read this aloud to the students, as complex vocabulary is used, while at the same time showing the steps in an image of a steam locomotive.

5. Show students a convection demonstration. Fill three-quarters of a shoebox-sized clear plastic container with room temperature water. Support it on four upside-down paper/foam cups. Use a pipette to place one quarter-sized red food coloring drop near one of the short edges of the container. Place a cup with hot water under the plastic container below the red food coloring drop. In approximately one minute, students should be able to see convection beginning to occur by observing that the red food coloring is moving upwards in the container. At this time, place one ice cube dyed with blue food coloring on the opposite short edge of the container. As the ice cube melts, students should see the cold blue water drifting to the bottom of the container and over towards where the red food coloring was originally placed.

Explain to students that a transfer of heat is occurring from the warm object to the cold object. They should also see the warm fluid rising while the cold blue fluid is sinking. Explain to them that this also happens in air. Explain that in a house, the second story will be warmer than the bottom story because warm fluid moves upward (due to it being less dense than the surrounding air). Cool fluid moves downward (due to it being more dense than the surrounding air). Convection is one of the ways in which heating occurs which in turn transfers energy. In this case matter (liquid) also physically moves. But energy transfer does not require that matter also move. In fact, light can transfer energy through space with no matter.

6. Show students the video “032 — How a Steam Locomotive Works”: <https://youtu.be/wZSoMxTb1ZM>

7. Ask students where they see convection occurring. (*The heated air in the firebox travels upwards and is forced through the pipes into the boiler.*)

8. Ask students where they see conduction occurring (remind them of the “Explore” ice cube activity). (*The heated air traveling through the pipes in the boiler heats up the metallic fire tubes and then the water surrounding the fire tubes.*)

9. Allow students time to discuss with one or two neighbors how the science behind a steam locomotive is related to energy and the activities they did. Have a few students share their ideas. (By this point they should realize that the activities they observed showed transfers of energy, as well as conversion of energy from one type to another, both of which also occur in a steam locomotive.)

## Assessing the Outcomes

### Evaluate

1. Explain to students they are going to work individually and provide two examples in which energy is transferred from place to place by sound, light, heat, or electrical currents. They will also diagram one transfer of energy in a steam locomotive.

2. Have students turn to page 31 to “What I’ve Learned about the Science behind a Steam Locomotive” in their student workbooks.

3. Once students have completed the assessment, have them put their pencils down and have a few students share their answers.
4. Collect the students' workbooks.
5. Explain to them that the next lesson on the Sierra Railway will help them understand how towns are formed and the Sierra Railway's role in the development of local communities.

## Lesson 3: The Science behind a Steam Locomotive — Worksheet: Answer Key

Note to the teacher: The answers provided are the “correct” answers. Students' answers will vary and some may also be wrong. This is acceptable. As students move through the stations during the “Explore” phase, and then share their ideas in the “Explain” phase, they will develop a better understanding of the concept of energy.

### Station 1: Energy Transfer through Sound — Balloon and Music

1. What do you feel the balloon do when the music is on and it is 5 cm from the radio speaker? *(The balloon vibrates.)*
2. What do you feel the balloon do when the music is on and it is 15 cm from the radio speaker? *(The balloon doesn't move or it vibrates less than when it's closer to the speaker.)*
3. What do you think causes the balloon to move when it is close to the speaker and music is playing? *(Sound is caused by waves traveling. The music coming from the speaker travels as waves through the air to the balloon. The waves hit the balloon and cause the balloon to move/vibrate.)*

### Station 2: Energy Transfer through Sound — Rice and Baking Pan

1. What happens to the rice when you bang the baking pan? *(The rice moves/jumps.)*
2. What do you think causes this to happen? *(Sound is caused by waves traveling. The banging sound travels as waves through the air to the homemade drum. The waves hit the skin of the drum and cause it to move up and down. Since the rice grains are on the skin of the drum, they also move {energy is transferred between them as a result of collisions}.)*

### Station 3: Energy Transfer through Radiation (Light) — Flashlight

1. Original temperature: *(Will vary.)*  
New temperature: *(Will vary.)*
2. Did the temperature of the area shined on by the flashlight increase (get hotter) or decrease (get colder)? *(Increase/get hotter.)*
3. What do you think causes this to happen? *(Energy is being transferred from the flashlight to the thermometer through lighting and heating of the thermometer.)*

### Station 4: Energy Transfer through Radiation (Light) — Sun

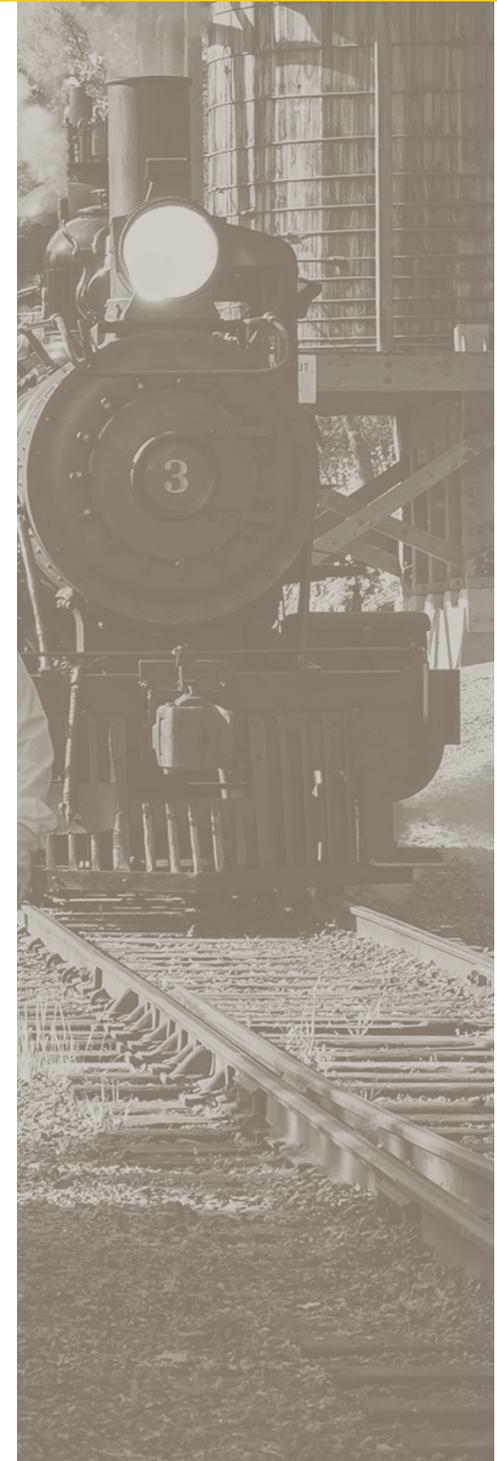
1. a. Time: *(Will vary.)*  
b. Room temperature: *(Will vary.)*
2. a. Time: *(Will vary.)*  
b. Outside temperature: *(Will vary.)*
3. Does the temperature increase (get hotter) or decrease (get colder)? *(If weather is warmer outside than inside: increase/get hotter.)*
4. What do you think causes this to happen? *(Energy is being transferred from the sunlight to the thermometer through lighting and heating of the thermometer.)*

### Station 5: Energy Transfer through Heating — Ice Cube

1. What happens when you hold the ice cube for 15 seconds with your hand flat? *(It melts.)*
2. What happens when you hold the ice cube for 15 seconds with your hand closed around the ice cube? *(It melts faster than when I had my hand flat.)*
3. What do you think caused the ice to melt more quickly with your hand closed around it? *(My hand is warmer than the ice cube. Heat is being transferred from my hand to the ice cube so the ice cube is heating up and melting. Energy is being transferred through heating.)*

### Station 6: Energy Transfer through Heating — Heating Pad

1. What do you feel when you hold your hand 30 cm away from the heating pad? **(Nothing.)**
2. What do you feel when you touch the heating pad? *(My hand gets warmer.)*



## Lesson 3: The Science Behind a Steam Locomotive

3. What do you think causes these two different feelings? (*When I hold my hand far away from the heating pad, my hand does not warm up. When I touch the heating pad, the heat from the pad moves to my hand. The energy is transferred from the heating pad to my hand through heating.*)

### **Station 7: Energy Transfer through Electric Currents — Series Circuit**

1. What happens when you turn on the switch? (*The light turns on.*)
2. What do you think is happening inside the batteries and wire that makes this happen? (*Charged particles move from the battery through the wire to the light bulb. When they move through the filament in the light bulb the filament is heated and gives off light [e.g., a fire gives off light and sound also]. Energy is being transferred through electric currents and heat. The charged particles continue to flow through the conductors as long as the switch is down.*)

### **Station 8: Energy Transfer through Electric Currents — Portable Light**

1. What happens when you turn on the switch? (*The light turns on.*)
2. What do you think is happening inside the cord and light that makes this happen? (*Charged particles move from the outlet through the cord to the light bulb. When they move through the filament in the light bulb the filament is heated and gives off light. Energy is being transferred through electric currents and heat. The charged particles continue to flow through the conductors as long as the light is turned on and plugged in.*)

### **Station 9: Kinetic (Movement) Energy to Kinetic Energy — Marbles**

1. What do the small marbles do when the large marble hits them? (*They move.*)
2. Where do the small marbles get their energy to move? (*They get energy from the large marble.*)
3. In this case does the large marble have to touch the small marbles in order for them to move? Why or why not? (*Yes. The kinetic energy is transferred from the large marble to the small marbles when they collide.*)

### **Station 10: Kinetic (Movement) Energy to Kinetic Energy — Dominoes**

1. What happens to the other dominoes after you push one of them? (*They fall /move.*)
2. Where do the other dominoes get their energy to move? (*They get energy from the one that fell on them.*)
3. In this case does one of the dominoes have to be pushed in order for the rest to move? Why or why not? (*Yes. The initial kinetic energy comes from being pushed. It is transferred between the dominos when they collide.*)

### **Station 11: Conversion of Energy: Kinetic Energy to Transfer through Sound — Drum**

1. What do you see when you hit the drum with the stick? (*The drum skin moves /vibrates.*)
2. What do you hear when you hit the drum with the stick? (*I hear a drumbeat.*)
3. In this case does the stick have to touch the drum in order for the two things above to happen? Why or why not? (*Yes. The drum stick has to hit the drum to make the drum skin move. When the drum skin moves, it produces sound that are waves that travel.*)

### **Station 12: Conversion of Energy: Transfer through Sound to Kinetic Energy — Tuning Fork**

1. What happens when you put the tip of the tuning fork into the water? (*The water splashes.*)
2. What do you think causes this to happen? (*The sound in the tuning fork is caused by the tuning fork moving back and forth. The sound travels to my ear and I hear it. Energy is being transferred through sound from the tuning fork to my ear. When I put the vibrating tip of the tuning fork in the water, the kinetic energy is transferred to the water because the two items are colliding. This causes the water to vibrate and splash.*)

## **Station 13: Conversion of Energy: Elastic Potential Energy to Kinetic Energy — Wind-up Toy**

1. What happens when you wind up the toy and set it on the ground? (*The toy moves.*)
2. What do you think happens inside the toy when you wind it? (*Winding up the toy creates a store of potential elastic energy in the mechanism in the toy. When I release the knob, the potential energy is converted into kinetic energy so the toy moves.*)

## **Station 14: Conversion of Energy: Kinetic Energy to Transfer through Sound and Heat — Bicycle Pump**

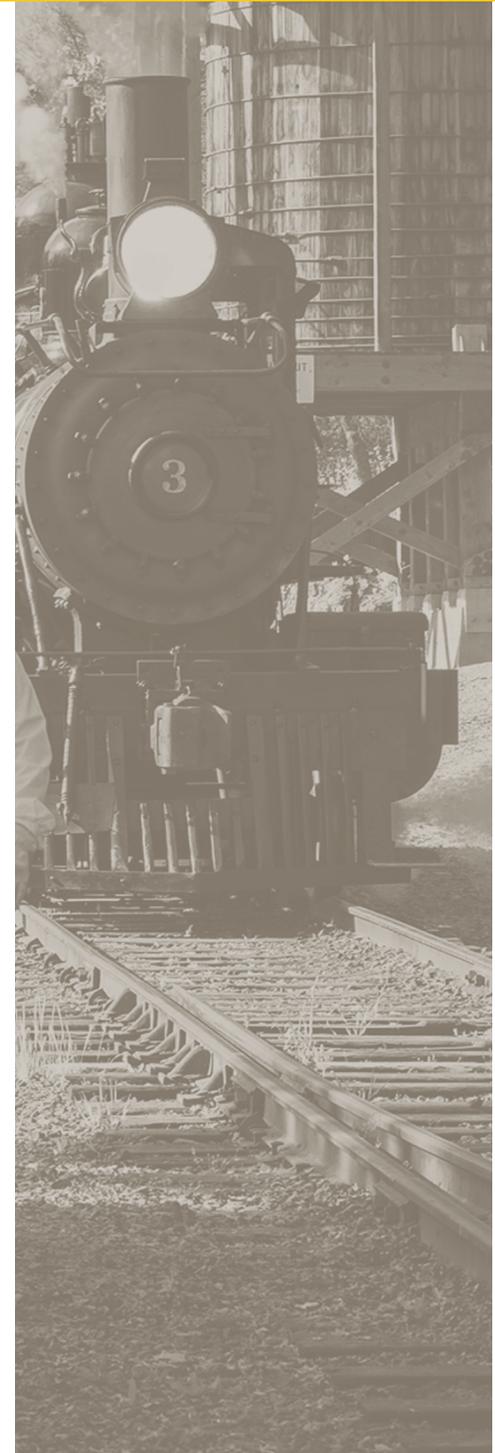
1. What do you hear when you pump the handle? (*A whoosh sound.*)
2. What do you feel when you touch the tube? (*It is warm, even hot.*)
3. What do you think causes these two things to happen? (*The kinetic energy—moving the pump up and down—is converted and transferred through sound and heat.*)

## **Student Workbook Questions:**

### **What I've Learned about The Science behind a Steam Locomotive**

In the spaces below, answer the two questions. Your answers to the first question do not need to be in complete sentences. Answer the second question by creating a diagram.

1. Provide at least two examples in which energy is transferred from place to place by sound, light, heat, or electrical currents. Describe where the energy starts and to where the energy is transferred. If you know, also write the type of energy.
  - a. Example 1: (*Answers will vary. Students may choose to describe any of the examples they experienced during the Explore activities, or any other example they are aware of.*)
  - b. Example 2: (*Answers will vary. Students may choose to describe any of the examples they experienced during the Explore activities, or any other example they are aware of.*)
2. Diagram one transfer of energy in a steam locomotive. (*Answers will vary. Diagrams may include any one of the following processes:*)
  - *Combustion (burning) of coal.*
  - *The heated gas travels through the fire tubes.*
  - *The boiling water results in steam (gas).*
  - *The piston moves. This is called kinetic energy.*
  - *When the wheel turns, it rubs on the track and other moving parts.*
  - *Gas (steam) is then pushed into the other side of the cylinder.*
  - *Some of the gas is let out of the cylinder.*



# Lesson 4: Planning a Town

## Subject Areas

History-Social Science

## Advanced Preparation Time

15 minutes

## Instructional Time

75 minutes

## Assessment Time

30 minutes

## Learning Outcomes

- Students will be able to describe the relationship between goods produced by natural systems and growth of towns.
- Students will be able to explain the relationship between movement of people and growth of towns.

## Key Vocabulary

**Migration:** the physical movement of people from one area to another

## Summary

This lesson focuses on the growth of towns, which is often a result of meeting the needs of newly arrived migrants. As people move into a community, they need to build homes, find employment, and buy food and supplies. As more people migrate to a central area, more jobs and resources are needed and typically become available. In small groups students brainstorm what they think is needed right away in a growing community to meet the needs of people and the resources that are needed to build a town. After sharing their ideas with their classmates, they return to the drawing board to design their town and answer questions that will ensure that migrants to their towns have their needs met. Students then view each other's designs and vote on the best one. This lesson helps students recognize that the Sierra Railway facilitated the expansion of the area's mining and timber industries due to its efficient transport of ore, timber, and other resources, or ecosystem goods. With this expansion came the creation of jobs and migration of people to growing communities.

## Materials

- Board: chalk or erase, if none available, a large piece of paper (one per class)
- Digital projector, computer, and screen if projecting the reading
- Paper: blank (two pieces per three or four students; consumable item)
- Paper: ruled (three pieces per three or four students; consumable item)
- Pencils (one per three or four students; consumable item)
- Pencils: colored (one set per three or four students; consumable item)
- Projectable Lesson 4 reading if applicable
- Student workbook (one per student; from Lesson 1; consumable item)
- Tape: standard office-style (one roll per three or four students)
- Word wall card: migration

- Writing tool: chalk or dry-erase pen as appropriate (at least one per class)

## Advanced Preparation

1. Organize students into groups of three or four.

## Prerequisite Knowledge

N/A

## Background

Towns along the route of the Sierra Railway experienced economic and population growth as a result of the railroad's presence. Internal migration of rail construction workers and business people increased the towns' populations. Teamsters reorganized and increased their number of routes to transport passengers and freight between train depots to other locations. Mining and timber industries benefited from more efficient transport of their ore, timber, and other resources. As their businesses profited, more jobs became available, bringing in more migrants and settlers.

In 1871, before the Sierra Railway, the Southern Pacific built a train depot in Stanislaus County. The town of Oakdale was established as a result of the depot's construction.

The town quickly became a freight center that created businesses for the town. Blacksmith, wagon shops and livery stables began operating to service the wagon teams, hotels, chop houses, and general stores opened to accommodate the teamsters. Farmers raised hay and barley to feed the animals.<sup>1</sup>

In six years, Oakdale's population doubled, reaching 1,000 residents. By 1881, it had churches and an elementary school. The Southern Pacific Railroad and Santa Fe Railroad made regular stops at the depot, connecting the town to other areas of California. When the Sierra Railway track was built, it connected the valley community

<sup>1</sup> Oakdale Chamber of Commerce California, "History of Oakdale," <https://www.oakdalechamber.com/history/>.

to the Sierra foothills. Oakdale formally incorporated in 1906. It established an irrigation system in 1909, expanding farming and ranching production.

Cooperstown's "ranchers in the area were especially enthused by the [Sierra Railway] railroads' arrival as it would permit them to load their cattle onto cars adjacent to their fields and thus eliminate the need to drive the cattle to market with the resulting weight loss."<sup>2</sup> Consequently, cattle (weighed at the time of sale) could be sold for more money, which in turn would support the ranchers and ultimately their community.

The general offices of the Sierra Railway were located in Jamestown. A roundhouse, turntable, and maintenance facilities were built and many jobs were established. Workers arrived and the town grew. Jamestown also changed dramatically as a result of an influx of capital and influence by Poniatowski, Bullock, Nevills, and their partners desiring to improve the town's infrastructure.

Anticipating the town's growth as a rail terminus, these two men [Bullock and Nevills], with local partners, had formed a Jamestown Improvement Company to promote one hundred and twenty acres of oak and pine-studded hillside as a residential area near the depot. This development . . . was known as the Pereira Addition.<sup>3</sup>

On December 19, 1897, the San Francisco Call reported:

Jamestown, the rail terminus, has undergone a magical change. It will be converted into a modern town with avenues and streets properly laid out, water, electric and sewer systems, the plans for which are now under consideration. A large hotel of sixty rooms is being erected, and the bank reorganized to do big business.<sup>4</sup>

Unfortunately, the Pereira Addition was still empty five years later. Miners and their families did live in Jamestown, but the town did not attract as many internal migrants and settlers as Bullock and his partners had originally hoped for. Jamestown did attract some

<sup>2</sup> Connery, "When the Railroad Came to Tuolumne," 1261. Deane, *Sierra Railway*, 15.

<sup>3</sup> Deane, *Sierra Railway*, 28.

<sup>4</sup> *San Francisco Call*, December 19, 1897, as quoted in Deane, *Sierra Railway*, 28.

tourists traveling between San Francisco and Yosemite, and many businesses and shops flourished in the town. The Nevills Hotel did initially attract tourists, but by 1903, many rooms were empty and the hotel had lost some of its luster.

The Sierra Railway arrived at the southern edge of the town of Sonora on February 26, 1899. A two-story depot was built—its first story made of white Columbia marble and second story made of Tuolumne County wood. "The depot was soon joined by a freight shed, then the Hales and Symons buildings and finally was completely dwarfed by the construction of the immense Standard Lumber Company facilities nearly surrounding it."<sup>5</sup> This infrastructure was connected to the business interests of Bullock and his partners and resulted in the growth of the town, adding employment opportunities and economic growth.

When the Sierra Railway finally made it to Angels Camp, the Calaveras Prospect wrote: The railroad will bring new men and ideas into our midst, and

<sup>5</sup> Connery, "When the Railroad Came to Tuolumne," 1266.



**Sonora Depot**

Photo courtesy of Tuolumne County Historical Society



**Mainstreet Jamestown**

Photo courtesy of Tuolumne County Historical Society

# Lesson 4: Planning a Town

## Standards Connections

### History-Social Science Standards

- 4.4. Students explain how California became an agricultural and industrial power, tracing the transformation of the California economy and its political and cultural development since the 1850s.
- 4.4.4. Describe rapid American immigration, internal migration, settlement, and the growth of towns and cities (e.g., Los Angeles).

## Environmental Principles and Concepts

- Principle I: The continuation and health of individual human lives and of human communities and societies depend on the health of the natural systems that provide essential goods and ecosystem services.
- Concept a. Students need to know that the goods produced by natural systems are essential to human life and to the functioning of our economies and cultures.

arouse us to the fact that we have been asleep while the world has moved along and left us. We should start by becoming better acquainted with our neighbors who, though only across the canyon, have had the benefit of rails longer than we — but who shall not surpass us now.<sup>6</sup>

People started new businesses in Angels Camp to meet the needs of newcomers.

Such traffic . . . was to cause a lively congestion of men and beasts on Angels Camp's Main Street when the trains began to run. Looking forward to that day, stores and saloons were stocking up, new businesses were opening and mining operations were reviving.<sup>7</sup>

The Sierra Railway route also brought together people from different towns for celebrations, holidays, dances, and sports games, through a faster and more comfortable mode of transportation. Excursion trains traveled between Sonora and Oakdale, and Sonora and Angels Camp for baseball games. In the early 1900s, Tuolumne County built its first high school in Sonora. Children from around the county, and even from Calaveras County, traveled on the Sierra Railway to attend school.

Even though the hotels and towns did not thrive to the extent that Bullock, Nevills, and their partners envisioned, the Sierra Railway influenced the growth of several towns and created a system of streamlined transport of freight and passengers.

## Procedures

### Introductory Information

1. Tell students they are going to read the next passage from Peter and Ruth's diary about the Sierra Railway and the growth of towns along the Sierra Railway route.
2. Distribute a student workbook to each student.
3. Have them turn to page 32 to the section entitled, "Planning a Town."

<sup>6</sup> *Calaveras Prospect*, as quoted in Deane, *Sierra Railway*, 81.

<sup>7</sup> Deane, *Sierra Railway*, 78.

4. Give students time to read the story. (Note: The story may be projected and read out loud by the teacher or students who are strong readers).

5. Ask a few student volunteers to share what they learned from Peter and Ruth. (The track to Jamestown is almost complete; goods that are being transported include everything from cows, groceries, timber, and lumber to coal, limestone, marble, and ores.)

6. Ask a few student volunteers to share the questions raised by Peter and Ruth. (What effects does train service have on the development of local communities and on people? What is needed right away by the people who move to a town? What resources are needed to create a town that meets the needs of migrants?)

7. Tell students they will work in small groups to brainstorm the development of a town. They will do this in two parts and share with each other after each part. Each group should elect a spokesperson.

### Presenting the New Material/Practicing the New Material: Step-by-Step Procedures

1. Assign students to work in groups of three to four members. Give each group a pencil and two sheets of ruled paper.

2. Explain to students they have about ten minutes to brainstorm answers to two questions (write these on the board):

- What is needed by people right away in a community that is now a stop along the Sierra Railway route?
- What resources are needed to build a town?

They should write their answers in bulleted form on the pieces of ruled paper. They can dedicate one piece of ruled paper to answer each question.

3. Conclude the brainstorming session and call on the spokesperson from each group to quickly share their ideas for both questions. Encourage groups to capture ideas they hear from other groups and integrate them into their own discussions after they regroup.

4. Hand out to each group one sheet of ruled paper, two blank sheets of paper, one roll of tape, and one package of colored pencils. Tell students they have thirty minutes to work as town planners in their small groups to integrate ideas they heard from their classmates, brainstorm new ideas, and design and draw a

town on the two blank pieces of paper. They can tape the two pieces of paper together vertically or horizontally. They should use the ruled piece of paper to record their answers to the following prompts: (write these on the board so students are reminded of them throughout the activity):

- What resources will migrants need?
- Where will these resources come from?
- How will the town recruit people with knowledge to build and manage the various industries?
- Where does the money come from to buy supplies and pay workers?

Explain that after thirty minutes they will post their town drawings and answers on the wall. The teams of town planners will examine all of the drawings and decide which plan is the best.

5. After thirty minutes, conclude the design activity and have the teams tape their drawings and accompanying information on the wall.

6. To start the next phase of the activity, student groups should move to the town plan of the group next to them so each group is starting at another group's plan. Tell them they will have two minutes at each design to observe the plan and review the information. Once they have seen all of the plans, they will come together and vote on the best town plan. They should be looking for the most practical design and the one that best answers the questions. Rotate students through each other's work by telling them to move every two minutes.

7. Once all students have reviewed all the plans, facilitate a town hall meeting in which they vote on the best plan. The winning group may give a brief speech emphasizing the key aspects of their town design and plan.

8. Keep students' town designs and plans since they will be used again in Lesson 6.

## Assessing the Outcomes

1. Have students turn to "What I've Learned about Planning a Town" in their student workbooks and answer the two questions to demonstrate what they have learned.

2. Once students have completed the assessment, have them put their pencils down and have a few students share their answers.
3. Collect the students' workbooks.
4. Explain to students that the next lesson on Sierra Railway will help them understand the connection between Sierra Railway and national railroad routes.

### Student Workbook Questions:

## What I've Learned about Planning a Town

In the spaces below, answer the two questions by writing complete sentences. Each answer should contain at least three sentences.

1. Describe the relationship between natural goods produced by natural systems and the growth of towns in the era of the Sierra Railway.

*(Natural goods in the area included timber, crops, animals, water, and minerals. Timber was used in buildings. Crops were mostly eaten. Some crops were used in clothing. Animals were eaten. Milk from cows became dairy products. The Sierra Railway transported many of these goods. People migrated to where there were resources and jobs. This resulted in towns growing along the Sierra Railway route.)*

2. Explain the relationship between movement of people and growth of towns.

*(People usually migrate to places where they can get jobs and food. This means they will move to places where goods and resources are available. The Sierra Railway connected many small towns with nearby natural resources. The resources were extracted and transported, and then used or sold for money. The Sierra Railway made the transport of goods easier. Therefore, the availability of resources increased. The people migrated near to where the resources were. These people needed houses to live in. They needed businesses to work in. Travelers needed hotels and places to eat. As towns began to grow, they attracted more people, including travelers. As the number of people in a town increased, so did the size of the town in order to meet their needs.)*

## SIERRA RAILWAY CO.

First Popular Excursion  
of the Season

**MAY 15, 1904**

—FROM—

**OAKDALE**

—TO—

**SONORA**

Account of Baseball Game

**Sonora vs. Oakdale**

Special train leaves Oakdale at 8 a.m.  
Returning leaves Sonora at 8 p.m.

Fare for Round Trip, : : : \$1.00

Music going and coming by the Oakdale Band.  
Take your best girl and come along.

S. H. SMITH, Gen. Pass. Agent.

**ONE DOLLAR**

**ROUND TRIP**

**EXCURSION TO ANGELS**

**Sunday, JUNE 19**

**BASE-BALL GAME**

**BETWEEN**

**ANGELS**

**AND**

**SONORA**

Don't miss this cheap rate a you may not get  
another such chance for this fine scenic trip.  
Train leaves Tuolumne 7:20 A.M., Sonora 8 A.M.  
Returning leaves Angels 7 P.M.

TUOL. INDEPENDENT PRINT, SONORA

# Lesson 5: A Network of Iron

## Subject Areas

English Language Arts, History-Social Science, Science

## Advanced Preparation Time

15 minutes

## Instructional Time

90 minutes

## Assessment Time

30 minutes

## Learning Outcomes

- Students will be able to diagram the concept of the need for energy to transport goods using the Sierra Railway as an example.
- Students will be able to describe the importance of the connection of the Sierra Railway to national railroad routes.

## Key Vocabulary

**Transcontinental:** crossing a continent

## Summary

In this lesson, students examine charts from historical annual reports of the Railroad Commission of California to uncover the influence and importance of the Sierra Railway in the growth of local industries and towns. Time charts of the two national railroads that shared a depot with the Sierra Railway at Oakdale show students the integral role the Sierra Railway had in transporting ecosystem goods from the valley and foothills to the rest of the country. Although the total length of the Sierra Railway line was relatively short, its influence was profound.

## Materials

- Digital projector, computer, and screen if projecting the reading
- Pencils (one per student; consumable item)
- Projectable Lesson 5 reading if applicable
- Student workbook (one per student; from Lesson 1; consumable item)
- Word wall card: transcontinental

## Advanced Preparation

1. Create groups of two students each.

## Prerequisite Knowledge

Students should have participated in Lesson 3: The Science behind a Steam Locomotive.

## Background

In 1869, the first transcontinental railroad in the United States was completed. Originally called the Pacific Railroad, it was later known as the Overland Route. The route connected Sacramento, California to Omaha, Nebraska / Council Bluffs, Iowa. In Council Bluffs, the route connected with eastern railroads. The Pacific Railroad was formed by two railroads: the Central Pacific Railroad, built from Sacramento to Utah, and the Union Pacific Railroad, built from Council Bluffs, Iowa to Utah. The two tracks met at Promontory Summit, Utah. The Overland Route reduced a six-month stage coach trip to a one week rail trip.

The second transcontinental railroad was completed in 1881 when the Southern Pacific Railroad connected with the Atchison, Topeka and Santa Fe Railway (Santa Fe) in Deming, New Mexico. The Southern Pacific ran from San Francisco to southern California and then to Arizona, New Mexico, Texas, and eventually to New Orleans. The Santa Fe route went from Kansas to New Mexico.

Both the Santa Fe and Southern Pacific railroads had depots at Oakdale. When the Sierra Railway line was completed between Tuolumne City, Angels Camp, Jamestown, and Oakdale, it made passenger and freight possible between the foothills of the Sierra Nevada and the Central Valley. Timber from the foothills and mining products from the Mother Lode could travel to all other



Overland Route

Illustration by Amy Hay

parts of the country due to the Sierra Railway's connection with the transcontinental railroads at Oakdale. The trains' timetables were coordinated to accommodate transfers at Oakdale that would support the efficient movement of passengers and freight.

The Southern Pacific and the Sierra Railway coordinated their efforts so well that they had "through cars" that passengers could take without having to get off of one company's car and board the other company's car.

The Sierra's No. 1, or down train, left Tuolumne City every morning at 6:18 a.m., arriving at Sonora at 7:00 a.m. and Oakdale at 9:50 a.m. On this train was the through combination coach which was taken directly to Stockton over S.P. [Southern Pacific] tracks, where passengers for San Francisco and way points transferred to S.P. main line trains.<sup>1</sup>

This convenience in transport of passengers and freight allowed for the expansion of local industries including mining, timber, and tourism.

## Procedures

### *Introductory Information*

1. Have students turn to a neighbor and share something they know about trains that crossed the United States, also called transcontinental railroads. Have a few students share what their partners said. (Answers will vary.)
2. Explain to them that they will be studying Sierra Railway charts and reading Ruth and Peter's diary to learn about the importance of the Sierra Railway and its connection to transcontinental railroads. They will also think about the Sierra Railway's need for energy to transport goods from the foothills of the Sierra Nevada to the valley in Oakdale.

### *Presenting the New Material/Practicing the New Material: Step-by-Step Procedures*

1. Distribute a student workbook to each student.
2. Have them turn to page 34 to the section entitled, "A Network of Iron: Part 1."

<sup>1</sup> Deane, *Sierra Railway*, 61.

3. Give students time to read the story. (Note: The story may be projected and read out loud by the teacher or students who are strong readers).
4. Ask a few student volunteers to share what they learned from Peter and Ruth. (The Sierra Railway road between Jamestown and Angels Camp is complete, the Sierra Railway will transport ores extracted from the mines along the Angels Camp Branch, timber and lumber companies are using the Sierra Railway to transport their goods.)
5. Tell them they are going to study several charts submitted by the Sierra Railway to the Board of Railroad Commissioners of California. They will work with a partner to answer a few questions based on the data. Everyone will be writing their answers in their workbooks.
6. Organize students into pairs.
7. Have them turn to page 35 to "A Network of Iron: Part 2" in their student workbook. Review the questions with them and point out the different charts they will use to answer the questions. Tell them they have thirty minutes to complete the task. Afterward they will read more of Ruth and Peter's diary and have a chance to change their answers if necessary.
8. Give students thirty minutes to complete the task. Assist them as necessary.
9. After thirty minutes, capture students' attention and tell them to turn to page 37 to "A Network of Iron: Part 3" in their student workbooks. Tell them they will read from Ruth and Peter's diary to learn more information about the questions they just answered. They may revise their answers as necessary. Give students time to read the story. (Note: The story may be projected and read out loud by the teacher or students). Allow them five minutes to make revisions to their answers, if needed.
10. Engage students in a discussion about the answers they wrote in Part 2 of this activity.

## Standards Connections

### *California Common Core English Language Arts Standards*

- Reading Standards for Informational Text K–5, Grade 4  
Key Ideas and Details 3. Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.

### *History-Social Science Standards*

- 4.4. Students explain how California became an agricultural and industrial power, tracing the transformation of the California economy and its political and cultural development since the 1850s.
- 4.4.1. Understand the story and lasting influence of the Pony Express, overland Mail Service, Western Union, and the building of the transcontinental railroad, including the contributions of Chinese workers to its construction.

### *Next Generation Science Standards*

- 4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and that their uses affect the environment.

## Environmental Principles and Concepts

- Principle 1: The continuation and health of individual human lives and of human communities and societies depend on the health of the natural systems that provide essential goods and ecosystem services.
- Concept a. Students need to know that the goods produced by natural systems are essential to human life and to the functioning of our economies and cultures.

# Lesson 5: A Network of Iron

## Assessing the Outcomes

1. Have students turn to page 40 to “What I’ve Learned about a Network of Iron” in their student workbooks. Tell them they will answer two questions to demonstrate what they have learned.
2. Once students have completed the assessments have them put their pencils down and have a few students share their answers.
3. Collect the students’ workbooks.
4. Explain to students that the next lesson on the Sierra Railway will help them understand how the Sierra Railway adapted over time as a result of changes in the local industry and how water played a role in the operation of the railway and growth of towns and cities.

## Student Workbook Questions:

### Network of Iron Parts 1 & 2

1. Study these two timetables (*below: Sierra Railway Schedule / Stagecoach Schedule*)
  - a. Which is faster? *Sierra Railway*
  - b. How do you know that? *Because from Sonora to Oakdale the Sierra Railway takes 2 hours and 50 minutes, and the stagecoach takes 10 hours.*
  - c. Which do you think can carry more products and goods at one time? *Train*
2. Study these three timetables (*below: Sierra Railway Company of California Schedule — Down Train / Santa Fe Schedule — North Bound / Southern Pacific Schedule — South Bound*)
  - a. What do you notice about the Oakdale station? *The Oakdale station shows up in all three timetables so all three railways have a stop there and passengers and freight can be exchanged*
3. Study these charts that describe products and goods transported by the Sierra Railway over time (*at right: Highlights of Products and Goods Transported by Sierra Railway Over Time*)
  - a. List two changes you notice happening over time: *Answers will vary but may include: the train carried more oil and less coal in later years, the train carried more lumber in later years.*
  - b. Does the Sierra Railway transport its own source of energy? *Yes*
  - c. List the two sources of energy you learned about in a previous lesson and that are also listed in the charts above. *Coal, oil*

#### SIERRA RAILWAY SCHEDULE

Departure	Time	Departure	Time	Arrival	Time
Carters/Summersville (Tuolumne City)	6:18 A.M.	Sonora	7:00 A.M.	Oakdale	9:50 A.M.

#### STAGECOACH SCHEDULE

		Sonora	9:00 A.M.	Oakdale	7:00 P.M.
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#### SIERRA RAILWAY SCHEDULE — DOWN TRAIN

Departure	Time	Arrival	Time	Arrival	Time	Arrival	Time
Carters/Summersville (Tuolumne City)	6:18 A.M.	Sonora	7:00 A.M.	Oakdale	9:50 A.M.		

#### SANTA FE SCHEDULE — NORTH BOUND

Oakdale	10:35 A.M.	Stockton	11:20 A.M.	Berkeley	2:05 P.M.	San Francisco	2:30 P.M.
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#### SOUTHERN PACIFIC SCHEDULE — SOUTH BOUND

Stockton	1:10 P.M.	Oakdale	2:30 P.M.	Merced	4:10 P.M.		
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## Highlights of Products and Goods Transported by Sierra Railway Over Time

(1 ton = 2,000 pounds)

(Data from Railroad Commission of the State of California Annual Reports)

Commodity	Total Freight Tonnage: Year 1900	Total Freight Tonnage: Year 1909	Total Freight Tonnage: July 1, 1913 – June 30, 1914	Total Freight Tonnage: July 1, 1914 – June 30, 1915
Grain	4,332	906	1,535	2,084
Flour	1,398	362	1,082	1,496
Hay	2,145	1,872	983	807
Fruits and vegetables	1,218	739	1,498	1,666
Livestock	202	27	124	390
Bituminous coal	2,897	406	485	685
Ores	5,512	13,862	13,158	12,332
Lumber	6,972	33,879	54,329	45,883
Petroleum and other oils	471	614	1,414	1,504
Sugar	400	123	569	574
Machinery	2,094	1,277	2,036	1,302
Household goods and furniture	336	146	639	651

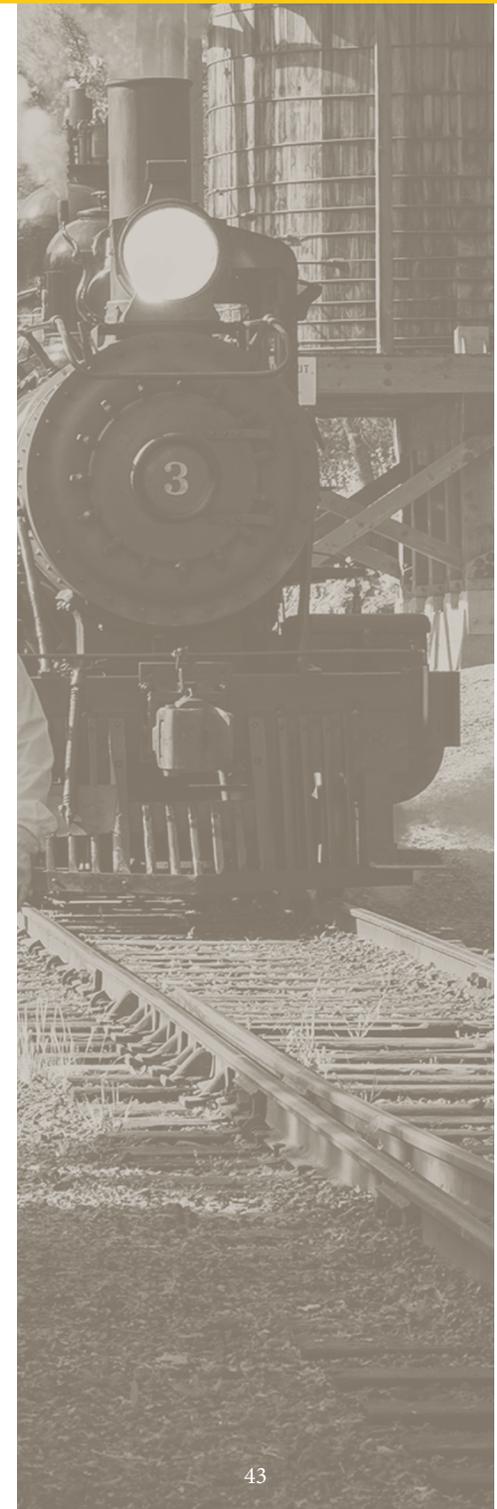
## What I've Learned about a Network of Iron Part 3

In the spaces below, answer the two questions. Answer the first question by drawing a diagram. Answer the second question by writing at least three sentences.

1. Diagram the concept of the need for energy to transport goods using the Sierra Railway as an example. (Possible answer: diagram of a Sierra Railway fireman putting coal or oil into the firebox of a locomotive. Sierra Railway cars are loaded with goods.)

2. Describe the importance of the connection of the Sierra Railway to transcontinental routes.

*(Before the Sierra Railway was built, goods were transported by stagecoach and mule trains. Compared to a train they cannot carry a lot at once. Stagecoaches and mule trains also took a long time to travel between towns. Once the Sierra Railway was built, goods were transported more efficiently to Oakdale. In Oakdale those goods could be transferred to the Southern Pacific Railroad or the Santa Fe Railroad to be taken to other parts of the country. The mining and timber products could be sold locally, as always. But the Sierra Railway made it easier for them to be transported across the country.)*



# Lesson 6: Driving Forces of Resources

## Subject Areas

History-Social Science, Science

## Advanced Preparation Time

15 minutes

## Instructional Time

60 minutes

## Assessment Time

30 minutes

## Learning Outcomes

- Students will be able to describe how the Sierra Railway adapted over time as a result of changes in industry in the area.
- Students will be able to describe the importance of water in the growth of towns and cities.

## Key Vocabulary

**Cause-and-effect-relationship:** a relationship between events or things in which one results from the other

**Dam:** a barrier built to hold back water. The water held behind it can be used for energy production, recreation, drinking, irrigation, or a combination of uses.

## Summary

Students begin this lesson by reading a diary entry written by Ruth and Paul. Now adults, they have children of their own. At this time, the Sierra Railway is involved in moving workers and materials to dam construction sites in the area. The purpose of these dams is to capture and store water for domestic and agricultural use, and harness hydropower to produce electricity. Working in small groups, students consider how the availability and delivery of water can influence the functioning of economies and cultures, specifically the towns they designed in Lesson 4. They analyze two scenarios, one in which water is a scarce resource and another in which it is abundant. They create two Cause and Effect Charts to document the two scenarios. They learn that the Sierra Railway adapted as time passed and local needs changed; it transported different materials and goods depending on the needs of local industries, people, and towns.

## Materials

- Digital projector, computer, and screen if projecting the reading
- List of discussion questions (included in Procedures)
- Pencils (one per student; consumable item)
- Projectable Lesson 6 reading if applicable
- Student workbook (one per student; from Lesson 1; consumable item)  
*(Note: reproducible Cause / Effect charts are in the Appendix)*
- Town designs and plans from Lesson 4
- Word wall cards: cause-and-effect relationship, dam

## Advanced Preparation

1. Gather town designs and plans from Lesson 4.
2. Recreate the groups of three to four students each from Lesson 4.

## Prerequisite Knowledge

Students need to have completed Lesson 4, or, be familiar with the growth of towns and cities.

## Background

The history of the Sierra Railway forms a web of cause-and-effect relationships. As the abundance of ecosystem goods, such as minerals and timber, diminished, and more people used personal automobiles for transport, the Sierra Railway turned to other industries. With growing populations in the Bay Area and local towns, the need for a reliable and constant source of water became more pressing. The Sierra Railway supported the construction of three dams between 1910 and 1940.

Construction work by the city of San Francisco began on the Hetch Hetchy Railroad track in February 1916 in order to assist in construction of the O’Shaughnessy Dam on the Tuolumne River. The new line met up with the Sierra Railway line at milepost twenty-six at Hetch Hetchy Junction. There, construction materials were transferred from the Sierra Railway to the Hetch Hetchy Railroad.

In 1921, the Sierra Railway completed an eight-mile spur to serve the Don Pedro Dam construction site. This dam was finished in 1924. In 1925, the Sierra Railway added another seven-mile spur to its line to reach the Melones Dam site on the Stanislaus River. The Melones Dam and powerhouse were completed between 1924 and 1926. In 1935, the Sierra Railway was contracted to operate the Hetch Hetchy Railroad to increase the height of the O’Shaughnessy Dam. The water from these dams was used for agriculture, irrigation, human consumption, or power generation, depending on the needs of the communities each dam was serving.

Besides its function in transportation, the Sierra Railway embarked on what would become a prominent role in the motion picture industry. Starring in its first silent movie in 1919, the railway, and its rolling stock, steam locomotives, and even a water tower, went on to be featured in over 200 movies, television shows, and commercials earning it the moniker “The Movie Railroad.”

## Procedures

### Introductory Information

1. Tell students today they are going to skip ahead more than 20 years in Peter and Ruth's diary and read what is happening with the Sierra Railway and neighboring towns in the 1920s.
2. Distribute a student workbook to each student.
3. Have them turn to page 42 to the section entitled, "Driving Forces of Resources."
4. Read the story aloud to the students as the vocabulary and length may make the reading harder for students.
5. Ask a few student volunteers to share what they learned from Peter and Ruth. (*The Sierra Railway built two new branches along its route to transport construction materials and workers to two dam projects, the Don Pedro Dam and the Melones Dam. The Sierra Railway was used to support the construction of the O'Shaughnessy Dam. The dam water is being used for agriculture and as hydropower for a power plant. One of the negative consequences of creating these dams is that land behind the dam is flooded and habitat is altered. This affects plants and animals and displaces human communities in its path.*)
6. Explain to students they will work in the same groups they were in during Lesson 4 to consider how water and its availability can influence the functioning of economies and cultures, specifically the towns they designed in Lesson 4. Using a Cause and Effect Chart, they will analyze two scenarios: one in which water is a scarce resource and another in which it is abundant.

### Presenting the New Material/Practicing the New Material: Step-by-Step Procedures

1. Assign students to their Lesson 4 work groups of three to four members. Hand each group their town design and plan so they can refer to it during this activity.
2. Have students turn to the first Cause and Effect Chart in the student workbook. This should be the "Water is Scarce" chart. Tell them that with their group mates they will consider the effects of water scarcity on their town. Remind them that sometimes an

"effect" becomes a cause for something else. They can add arrows and boxes to their charts as they feel necessary. Explain that they may be called on to share their charts with their classmates.

2. Give student groups about ten minutes to consider and document the first scenario. Each student should complete the workbook chart even if the group members write the same information.
3. Tell students to turn to the next Cause and Effect Chart in the student workbook. This should be the "Water is Abundant" chart. Tell them they will consider the effects of abundant water supplies on their town. As before, they can add arrows and boxes to their charts as they feel necessary. Explain that they may be called on to share their charts with their classmates.
5. Give student groups about ten minutes to consider and document the second scenario. Each student should complete the workbook chart even if the group members write the same information.
6. Capture students' attention. Call on one representative from each group to share either their "Water is Scarce" or "Water is Abundant" chart.
7. Remind students that a dam can create a water source as well as hydropower for electricity for a community. Facilitate a class discussion (questions suggested below) to help students assess the positive and negative consequences of a dam. Ideally, arrange students in a circle so they can talk with each other to move the conversation forward. Encourage them to engage in an academic conversation by asking for clarification, summarizing, paraphrasing, and building on each other's ideas.<sup>1</sup>

### Questions:

1. What are the effects of building a dam on the environment? (*The land behind the dam is flooded, resulting in animals and plants possibly dying or needing to move. Food and water sources for animals and plants change; fish that lived in the river can no longer migrate up and down the river; silt and sediment that once flowed down the river will now be trapped in the lake behind the dam.*)

<sup>1</sup> Zwiers, *Academic Language & Literacy*, <http://jeffzwiers.org>.

## Standards Connections

### History-Social Science Standards

- 4.4. Students explain how California became an agricultural and industrial power, tracing the transformation of the California economy and its political and cultural development since the 1850s.
- 4.4.4. Describe rapid American immigration, internal migration, settlement, and the growth of towns and cities (e.g., Los Angeles).

### Next Generation Science Standards

- 4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and that their uses affect the environment.

## Environmental Principles and Concepts

- Principle I: The continuation and health of individual human lives and of human communities and societies depend on the health of the natural systems that provide essential goods and ecosystem services.
- Concept a. Students need to know that the goods produced by natural systems are essential to human life and to the functioning of our economies and cultures.
- Concept b. Students need to know that the ecosystem services provided by natural systems are essential to human life and to the functioning of our economies and cultures.

2. What are the effects on human communities of building a dam? *(Water is captured and stored for drinking and irrigation. Communities behind the dam become flooded. There are changes to the availability of water. Hydropower harnesses energy and the resulting electricity can change lifestyles, e.g., staying up later because of indoor lighting, improving efficiency with machinery and kitchen appliances. There is a change in the visual landscape. Jobs are created during construction and operation of the dam. Water rights may change and fishing in the river downstream from the dam changes.)*

### Assessing the Outcomes

1. Have students turn to page 46 to “What I’ve Learned about Driving Forces of Resources” in their student workbooks. Tell them they will answer two questions to demonstrate what they have learned.
2. Once students have completed the assessment, have them put their pencils down and have a few students share their answers.
3. Collect the students’ workbooks.
4. Explain to students that they have completed the unit on the Sierra Railway and in the unit assessment they will synthesize, or put together, everything they have learned over the last several lessons.

### Student Workbook Questions:

## What I’ve Learned about Driving Forces of Resources

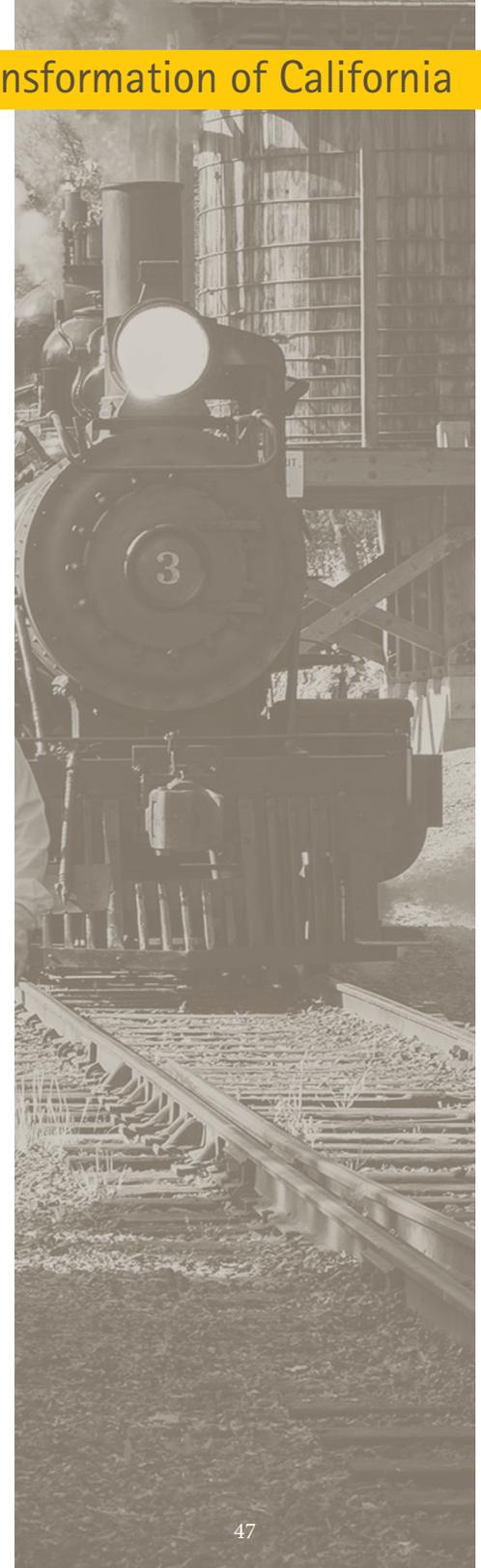
### Questions:

In the spaces below, answer the two questions using complete sentences. Each answer should contain at least three sentences.

1. Describe how the Sierra Railway adapted over time as a result of changes to industry in the area. *(The Sierra Railway transported less timber and mining freight in the 1920s. Luckily it was featured in some movies. This was good for the train and the towns. The film crews needed places to eat and sleep in town. The Sierra Railway was also used to build dams. It transported construction materials and workers.)*

2. Describe the importance of water in the growth of towns and cities. *(Students should be able to describe the effects they documented during the activity. A reliable, safe, and clean water source encourages settlement because the water can be used for drinking, cooking, bathing, and irrigating crops. People initially used water drawn from wells or from rivers and lakes for these needs. But as the needs grew, new sources needed to be built. Creating a dam resulting in a reservoir made the water source more reliable and easier to control. This water could also be used in towns for firefighting and sanitation.)*

# Appendix: Reproducibles



## Railtown 4th Grade Unit Plan — Unit Assessment Traditional The Sierra Railway and the Transformation of California

### Part 1. Choose the best answer (2 points each)

1. Choose the event that did NOT happen during the history of the Sierra Railway.
  - a. difficulty obtaining right-of-way
  - b. locomotives were fueled by coal
  - c. line extended into Yosemite National Park
  - d. transported timber, ores, cattle
2. \_\_\_\_\_ is the physical movement of people from one area to another.
  - a. extraction
  - b. migration
  - c. resource
  - d. switchback
3. A train car must run on two \_\_\_\_\_ rails in order for the car to stay on the tracks.
  - a. perpendicular
  - b. parallel
  - c. triangular
  - d. circular
4. Which of these does NOT describe a way the Sierra Railway made money?
  - a. transport of timber
  - b. passenger tourism
  - c. building of dams
  - c. aerial tramway
5. Which geographic feature made laying the track challenging:
  - a. rivers
  - b. canyons
  - c. mountains
  - d. all of the above

**Part 2. Answer each question with a sentence or short paragraph (5 points each)**

11. List two engineering problems the Sierra Railway engineer encountered and describe one solution for each problem.

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12. Describe the relationship between goods produced by natural systems and the growth of towns.

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13. Describe why the connection at Oakdale between the Sierra Railway and the Southern Pacific Railroad or the Santa Fe Railway was so important in the growth of the economy and towns.

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14. Describe why towns, cities, and farms need access to reliable water sources in order to experience economic and population growth.

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**Part 3. Follow the directions in the question below (10 points)**

15. Circle in the diagrams on the next page at least two transfers of energy that take place while a locomotive is functioning. In the lines underneath the diagram, describe the transfers of energy.

**Part 4. Follow the directions in the question below (20 points)**

16. Write one paragraph with at least five sentences summarizing the lasting influence of the Sierra Railway in the local region by including multiple cause and effect sequences you have learned throughout the unit.

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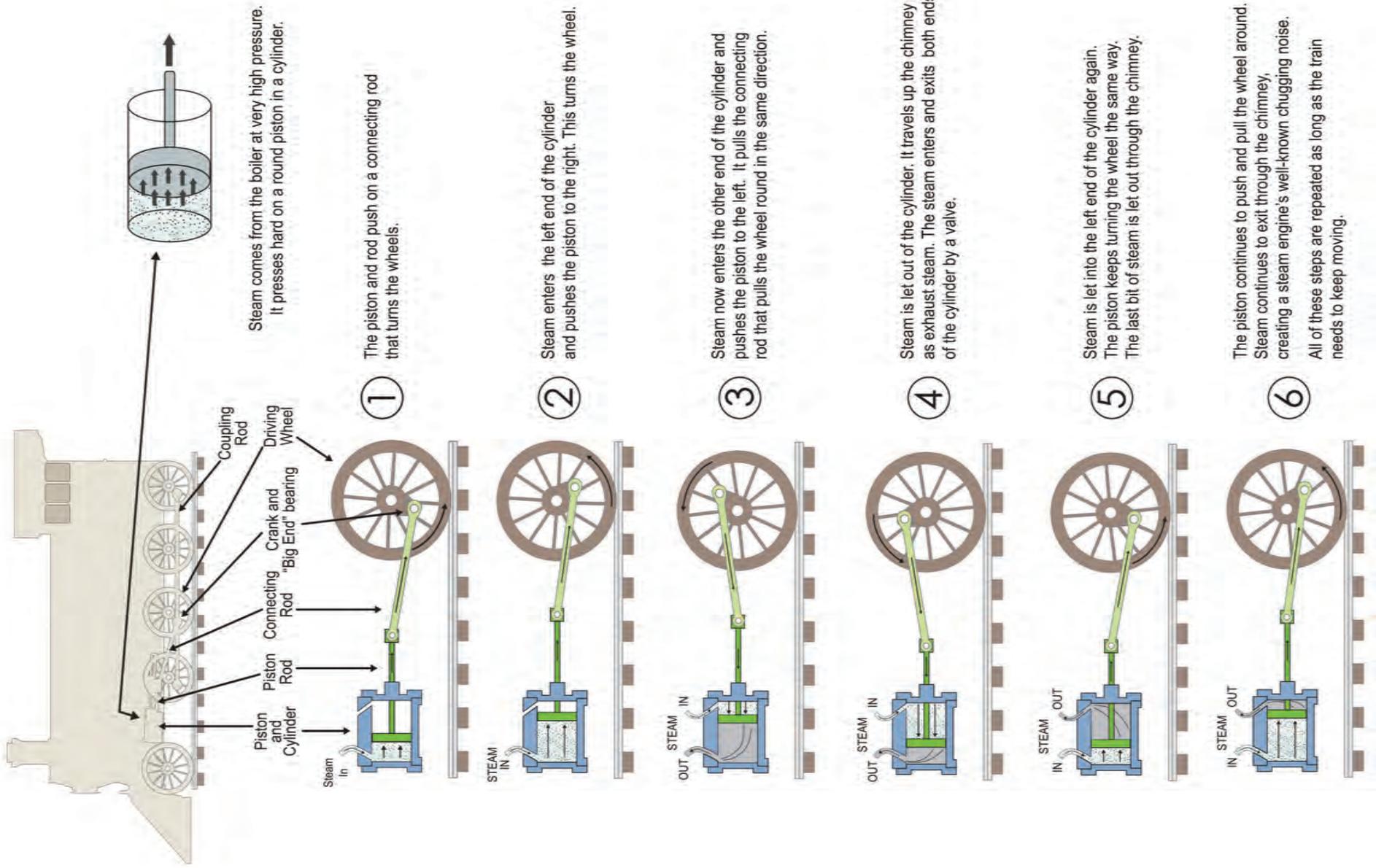
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## Sierra Railway of California Poster Session Q & A

### Directions

1. Review the posters presented by your colleagues. Choose two that are especially interesting to you.
2. In the spaces provided below, write one question for each one of the posters you chose in Step 1. The question should not be a “yes or no” question. Rather, it should lead to a thoughtful discussion about a cause or effect your colleague has included on the poster.

#### Question 1

Colleague's name: \_\_\_\_\_

Question asked: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Response: \_\_\_\_\_

\_\_\_\_\_

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#### Question 2

Colleague's name: \_\_\_\_\_

Question asked: \_\_\_\_\_

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Response: \_\_\_\_\_

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\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

## **Station 1: Energy Transfer through Sound — Balloon and Music**

### *Instructions:*

1. Turn on the music.
2. Hold the inflated balloon about 5 cm from the radio speaker. What do you feel?
3. Hold the inflated balloon about 15 cm from the radio speaker. What do you feel?
4. Complete your worksheet.
5. Reset the station.

*Lesson 3: The Science behind a Steam Locomotive — Station Cards*

## **Station 3: Energy Transfer through Radiation (Light) — Flashlight**

### *Instructions:*

1. Place the thermometer on the table.
2. Record the temperature.
3. Turn the flashlight on and hold it 10 cm from the thermometer. Watch the wall clock and wait 30 seconds.
4. Is the temperature of the area shined on by the flashlight increasing (getting hotter) or decreasing (getting colder)?
5. Complete your worksheet.
6. Reset the station.

*Lesson 3: The Science behind a Steam Locomotive — Station Cards*

## **Station 2: Energy Transfer through Sound — Rice and Baking Pan**

### *Instructions:*

1. Place a pinch of rice grains on the drum.
2. Hold the baking pan near the drum and hit the pan with your hand.
3. Have your partners observe what happens to the rice grains.
4. Complete your worksheet.
5. Reset the station.

*Lesson 3: The Science behind a Steam Locomotive — Station Cards*

## **Station 4: Energy Transfer through Radiation (Light) — Sun**

### *Instructions:*

1. Go outside and check the temperature on the thermometer.
2. Is the temperature increasing (getting hotter) or decreasing (getting colder)?
3. Complete your worksheet.
4. Reset the station.

*Lesson 3: The Science behind a Steam Locomotive — Station Cards*

## **Station 5: Energy Transfer through Heating — Ice Cube**

### *Instructions:*

1. Hold your hand out flat.
2. Place an ice cube from the “new” container on your hand. For 15 seconds observe what happens.
3. Close your hand around the ice cube. For 15 seconds observe what happens.
4. Place the ice cube in the “used” container.
5. Dry off any wet spots.
6. Complete your worksheet.
7. Reset the station.

*Lesson 3: The Science behind a Steam Locomotive — Station Cards*

## **Station 7: Energy Transfer through Electric Currents — Series Circuit**

1. Turn the switch on. What happens?
2. Complete your worksheet.
3. Reset the station.

*Lesson 3: The Science behind a Steam Locomotive — Station Cards*

## **Station 6: Energy Transfer through Heating — Heating Pad**

1. Make sure the heating pad is set to “low.”
2. Place your hand 30 cm away from the heating pad for 5 seconds. What do you feel?
3. Place your hand on top of the heating pad for 5 seconds. What do you feel?
4. Complete your worksheet.
5. Reset the station.

*Lesson 3: The Science behind a Steam Locomotive — Station Cards*

## **Station 8: Energy Transfer through Electric Currents — Portable Light**

1. Turn the light on. What happens?
2. Complete your worksheet.
3. Reset the station.

*Lesson 3: The Science behind a Steam Locomotive — Station Cards*

### **Station 9: Kinetic (Movement) Energy to Kinetic Energy — Marbles**

1. Arrange the small marbles in a group. Place the large marble 15 cm away from the rest of the marbles.
2. With your fingers, flick the large marble so it moves toward and hits the small marbles. What do the small marbles do?
3. Complete your worksheet.
4. Reset the station.

*Lesson 3: The Science behind a Steam Locomotive — Station Cards*

### **Station 11: Conversion of Energy: Kinetic Energy to Transfer through Sound — Drum**

1. Pick up the drumstick and hit the drum with it.
2. What happens?
3. Complete your worksheet.
4. Reset the station.

*Lesson 3: The Science behind a Steam Locomotive — Station Cards*

### **Station 10: Kinetic (Movement) Energy to Kinetic Energy — Dominoes**

1. Arrange the dominoes so they are standing up near, but not touching, each other.
2. Gently push one of the outer dominoes so it falls on the nearest domino. What happens?
3. Complete your worksheet.
4. Reset the station.

*Lesson 3: The Science behind a Steam Locomotive — Station Cards*

### **Station 12: Conversion of Energy: Transfer through Sound to Kinetic Energy — Tuning Fork**

1. Hold the tuning fork in your hand.
2. Hit it against the floor and then quickly put just the tip into the container of water. What happens?
3. Complete your worksheet.
4. Reset the station.

*Lesson 3: The Science behind a Steam Locomotive — Station Cards*

### **Station 13: Conversion of Energy: Elastic Potential Energy to Kinetic Energy — Wind-up Toy**

1. Wind up the toy by turning the knob.
2. Set the toy on the ground. What happens?
3. Complete your worksheet.
4. Reset the station.

*Lesson 3: The Science behind a Steam Locomotive — Station Cards*

### **Station 14: Conversion of Energy: Kinetic Energy to Transfer through Sound and Heat — Bicycle Pump**

1. Move the handle of the bicycle pump up and down at least 15 times.
2. What do you hear?
3. Move the handle of the pump up and down five more times. Touch the tube where the air comes out while you're pumping the handle. What do you feel?
4. Complete your worksheet.
5. Reset the station.

*Lesson 3: The Science behind a Steam Locomotive — Station Cards*

*Station 1: Energy Transfer through Sound — Balloon and Music*

1. What do you feel the balloon do when the music is on and it is 5 cm from the radio speaker?

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2. What do you feel the balloon do when the music is on and it is 15 cm from the radio speaker?

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3. What do you think causes the balloon to move when it is close to the speaker and music is playing?

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*Station 2: Energy Transfer through Sound — Rice and Baking Pan*

1. What happens to the rice when you bang the baking pan?

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2. What do you think causes this to happen?

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*Station 3: Energy Transfer through Radiation (Light) — Flashlight*

1. Original temperature: \_\_\_\_\_ New temperature: \_\_\_\_\_

2. Did the temperature of the area shined on by the flashlight increase (get hotter) or decrease (get colder)?

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3. What do you think causes this to happen?

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**Station 4: Energy Transfer through Radiation (Light) — Sun**

1. a. Time: \_\_\_\_\_  
b. Room temperature: \_\_\_\_\_
2. a. Time: \_\_\_\_\_  
b. Outside temperature: \_\_\_\_\_
3. Does the temperature increase (get hotter) or decrease (get colder)?

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4. What do you think causes this to happen?

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**Station 5: Energy Transfer through Heating — Ice Cube**

1. What happens when you hold the ice cube for 15 seconds with your hand flat?

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2. What happens when you hold the ice cube for 15 seconds with your hand closed around the ice cube?

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3. What do you think caused the ice to melt more quickly with your hand closed around it?

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**Station 6: Energy Transfer through Heating — Heating Pad**

1. What do you feel when you hold your hand 30 cm away from the heating pad?

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2. What do you feel when you touch the heating pad?

3. What do you think causes these two different feelings?

**Station 7: Energy Transfer through Electric Currents — Series Circuit**

1. What happens when you turn on the switch?

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2. What do you think is happening inside the batteries and wire that makes this happen?

**Station 8: Energy Transfer through Electric Currents — Portable Light**

1. What happens when you turn on the switch?

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2. What do you think is happening inside the cord and light that makes this happen?

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**Station 11: Conversion of Energy: Kinetic Energy to Transfer through Sound — Drum**

1. What do you see when you hit the drum with the stick?

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2. What do you hear when you hit the drum with the stick?

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3. In this case does the stick have to touch the drum in order for the two things above to happen? Why or why not?

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**Station 12: Conversion of Energy: Transfer through Sound to Kinetic Energy — Tuning Fork**

1. What happens when you put the tip of the tuning fork into the water?

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2. What do you think causes this to happen?

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**Station 13: Conversion of Energy: Elastic Potential Energy to Kinetic Energy — Wind-up Toy**

1. What happens when you wind up the toy and set it on the ground?

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2. What do you think happens inside the toy when you wind it?

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*Station 14: Conversion of Energy: Kinetic Energy to Transfer through Sound and Heat — Bicycle Pump*

1. What do you hear when you pump the handle?

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2. What do you feel when you touch the tube?

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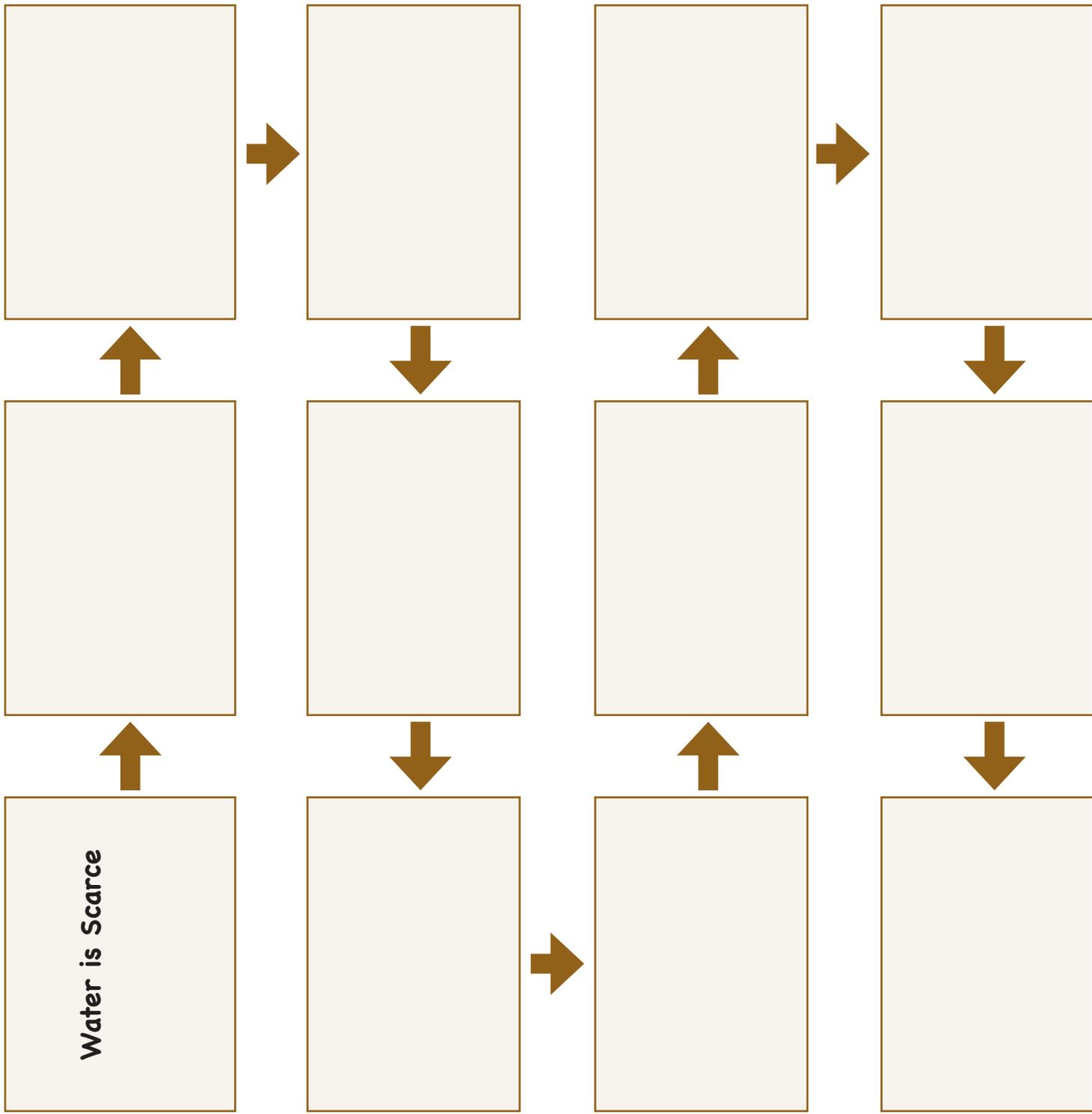
3. What do you think causes these two things to happen?

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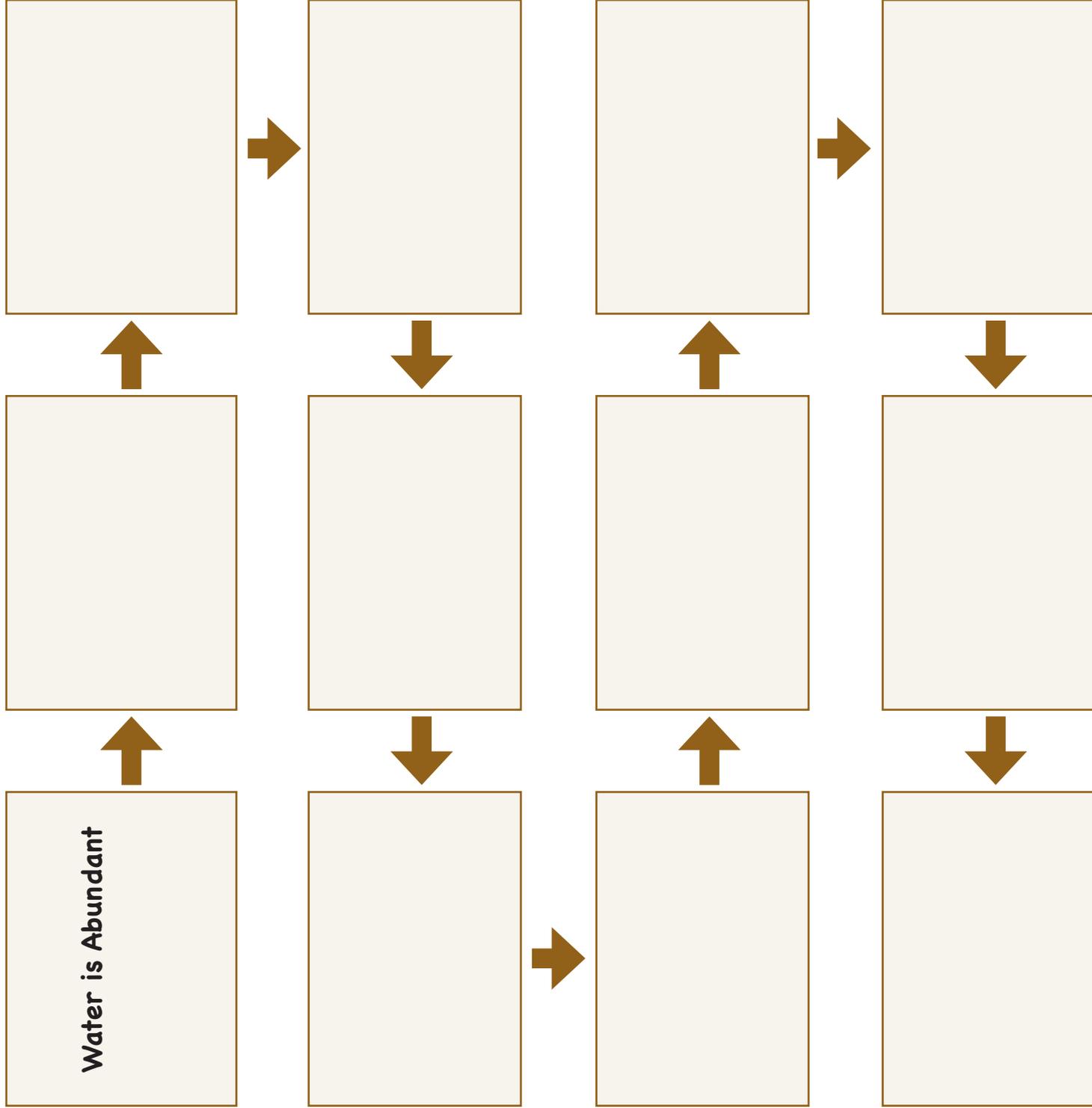
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Cause and Effect Charts



Lesson 6: Cause and Effect Chart





# Appendix: Projectables

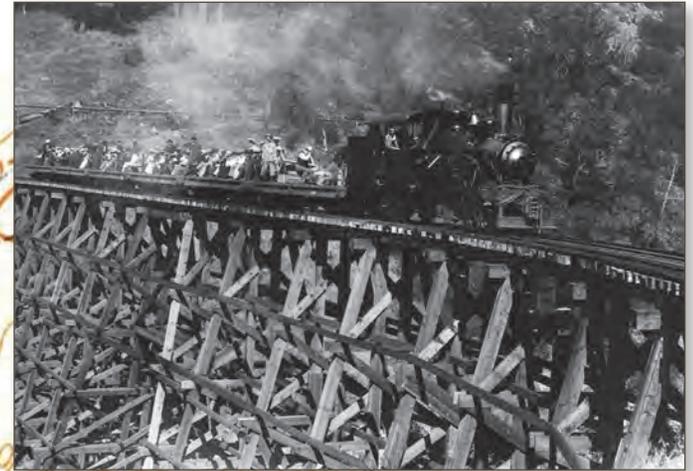
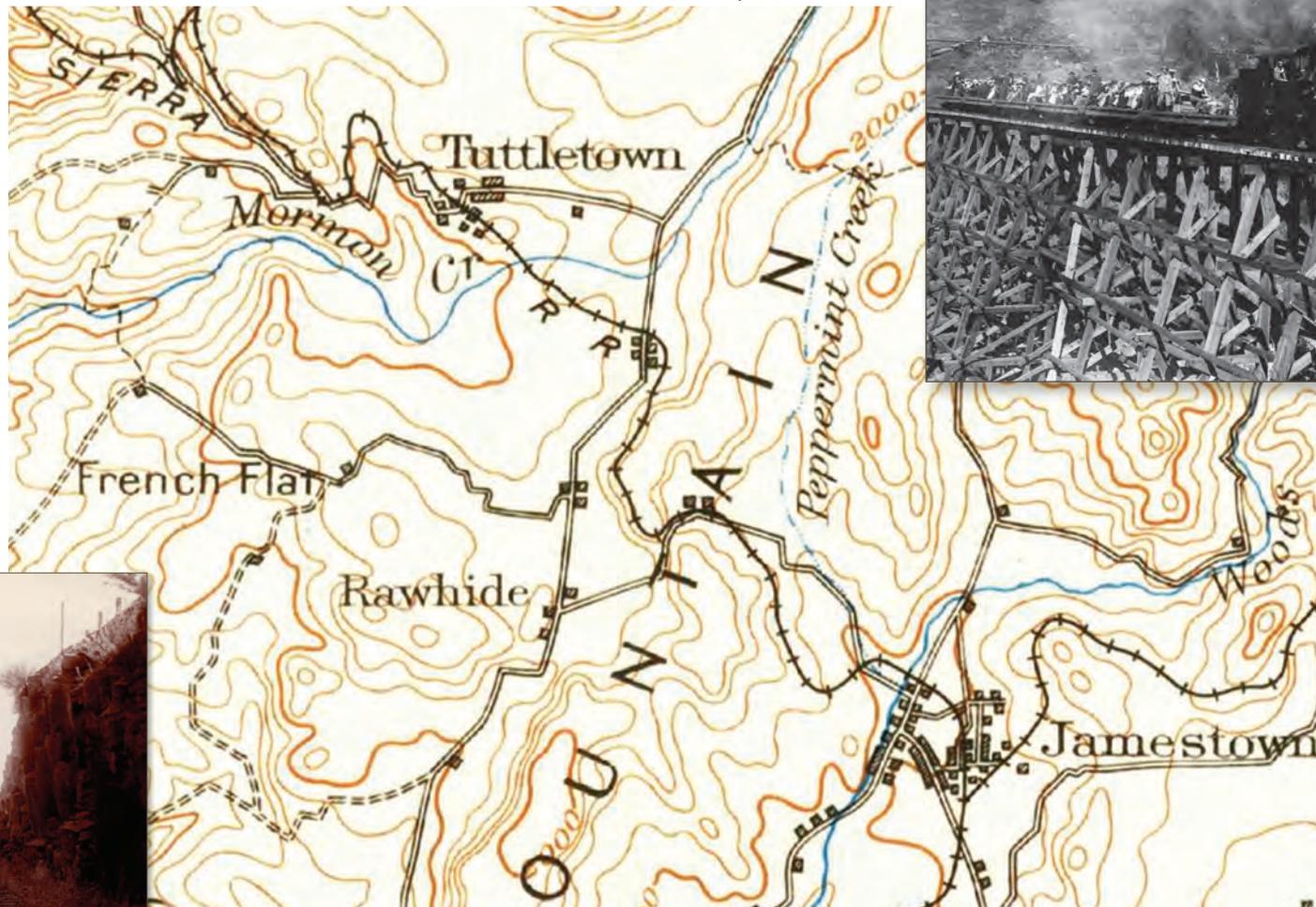




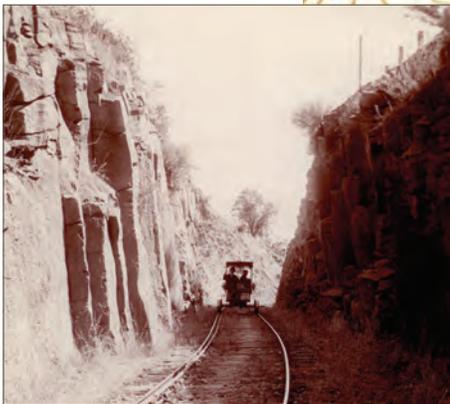
**Stanislaus River Bridge**  
Photo courtesy of Calaveras County Historical Society



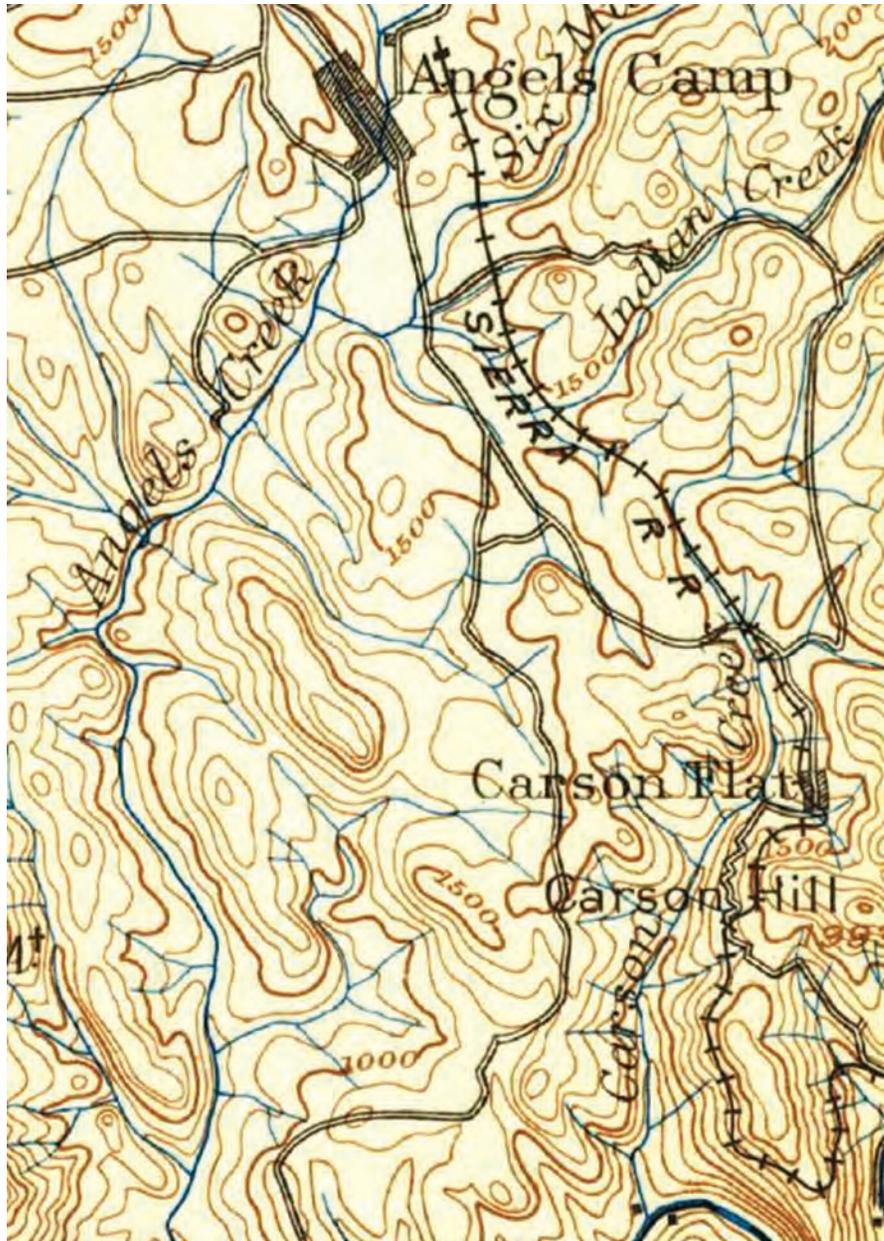
**Angels Line Switchback**  
Photo courtesy of Tuolumne County Historical Society



**Woods Creek Trestle**  
Photo courtesy of Tuolumne County Historical Society



**Table Mountain Cut**  
Photo courtesy of Calaveras County Historical Society



**Gee Whiz Point**  
Photo courtesy of Tuolumne County Historical Society



**Angels Line Switchback**  
Photo courtesy of Tuolumne County Historical Society

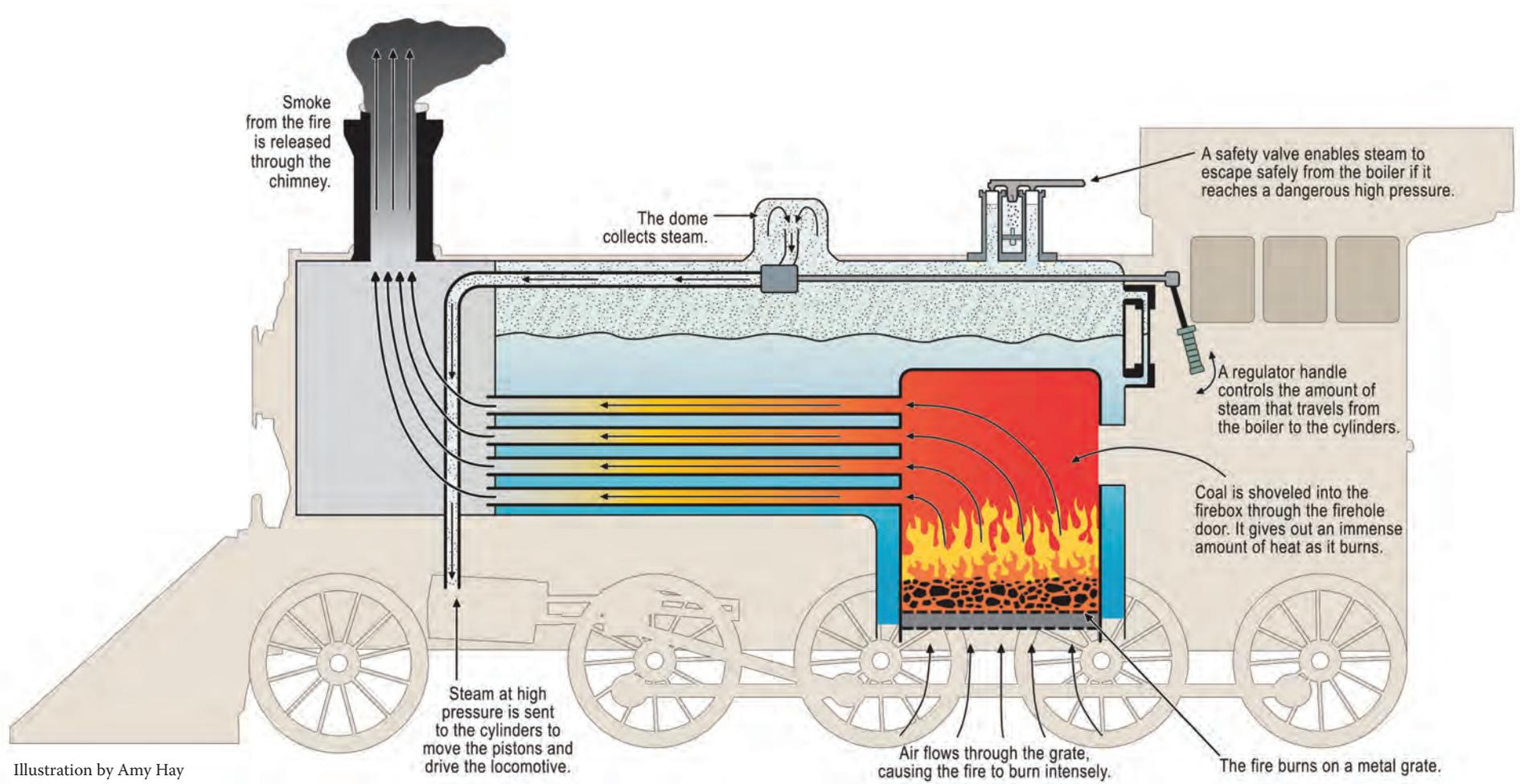
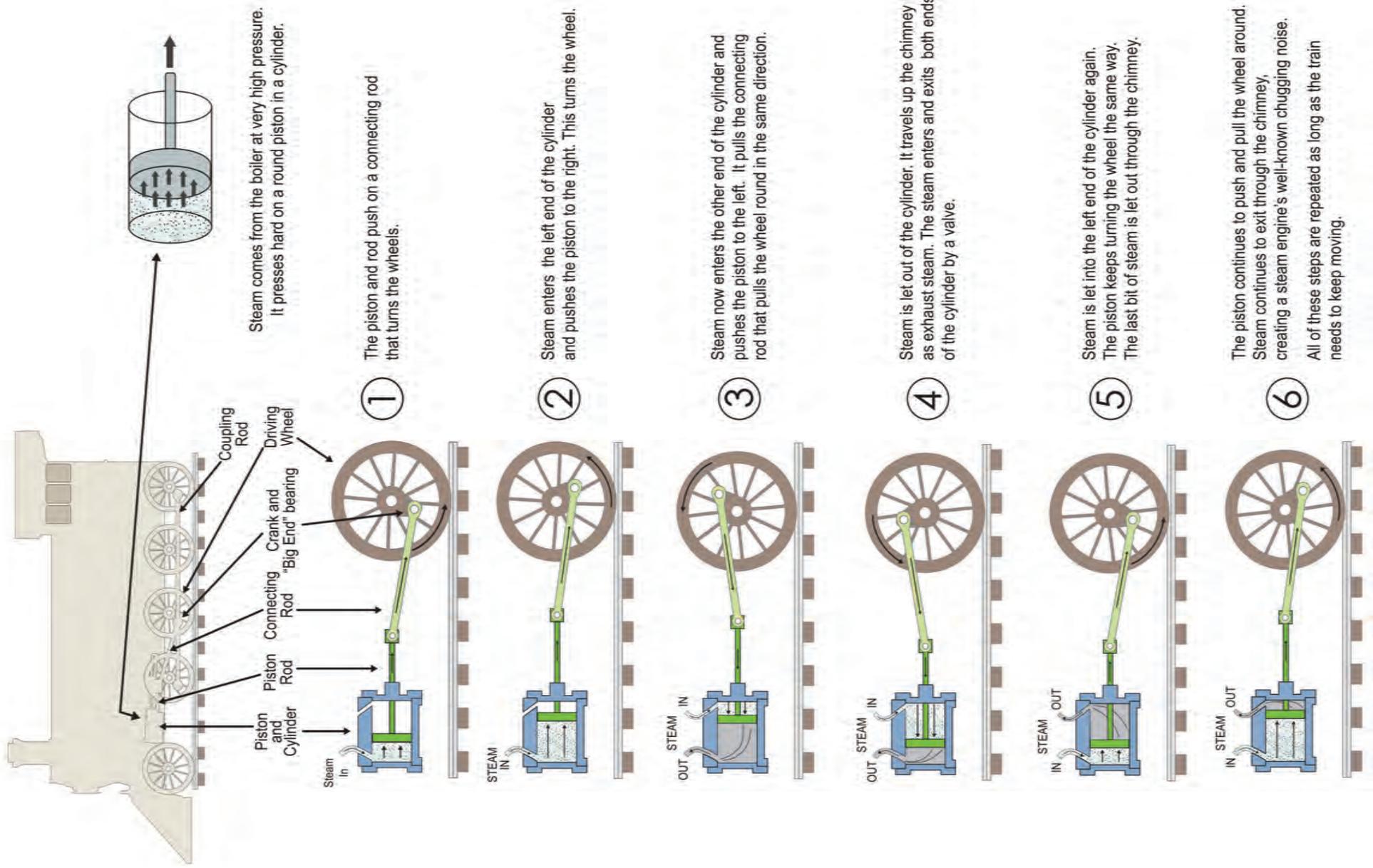


Illustration by Amy Hay



Steam comes from the boiler at very high pressure. It presses hard on a round piston in a cylinder.

1 The piston and rod push on a connecting rod that turns the wheels.

2 Steam enters the left end of the cylinder and pushes the piston to the right. This turns the wheel.

3 Steam now enters the other end of the cylinder and pushes the piston to the left. It pulls the connecting rod that pulls the wheel round in the same direction.

4 Steam is let out of the cylinder. It travels up the chimney as exhaust steam. The steam enters and exits both ends of the cylinder by a valve.

5 Steam is let into the left end of the cylinder again. The piston keeps turning the wheel the same way. The last bit of steam is let out through the chimney.

6 The piston continues to push and pull the wheel around. Steam continues to exit through the chimney, creating a steam engine's well-known chugging noise. All of these steps are repeated as long as the train needs to keep moving.